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Species, provenance, and progeny tests of the genus *Larix* by the Petawawa National Forestry Institute

T.J.B. Boyle, T.C. Nieman, S. Magnussen, and J. Veen

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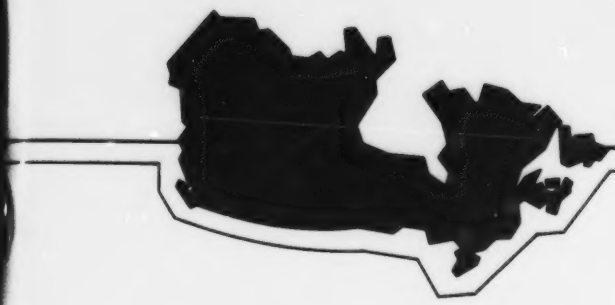
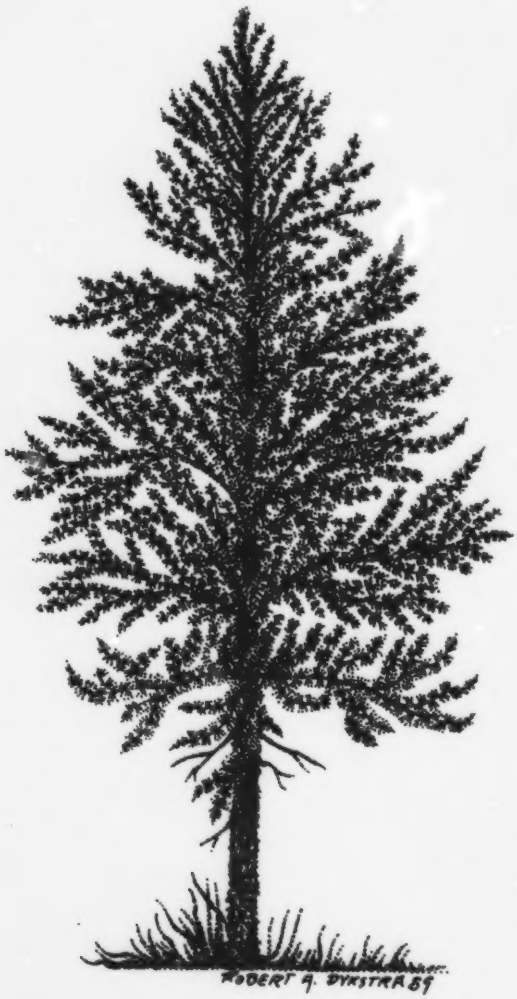
Petawawa National Forestry Institute





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ABSTRACT

Information is presented on all experiments established by the Tree Genetics and Breeding Project of Forestry Canada's Petawawa National Forestry Institute of the genus *Larix* over the last 65 years. A total of 128 experiments and 906 seedlots are listed. The most valuable and well-designed experiments are discussed in detail and recommendations are presented for the use of native and exotic larch species in eastern Canada.

RÉSUMÉ

Les auteurs décrivent toutes les expériences menées sur le genre *Larix* par le groupe du Programme de l'amélioration génétique des arbres à l'Institut forestier national de Petawawa de Forêts Canada. Au cours de 65 ans jusqu'ici écoulés, on compte en tout 125 expériences et 906 lots de semences. Les expériences les plus importantes et les mieux planifiées sont décrites en détail, accompagnées de recommandations quant à l'emploi des mélèzes indigènes ou exotiques dans l'est du Canada.

INTRODUCTION

The investigation of genetic variation and performance of larch species has been actively pursued at the Petawawa National Forestry Institute (PNFI) since 1926. With larch tree improvement programs currently receiving a high priority in many regions of Canada, a review of research on the genetics of larch species at PNFI and interpretation of the results is clearly desirable. The present report summarizes all experiments on the genetics of larch established at PNFI and discusses the results of those most relevant to current improvement work. Results of provenance and progeny tests of these species and hybrids having potential commercial value in eastern Canada are presented in the text. In addition, details are given in Appendix II of all larch experiments conducted by the Tree Genetics and Breeding Project at PNFI, with experiments listed in numerical order (the experiment number itself is merely an arbitrary numer allocated for record-keeping purposes). Appendix I lists all seedlots of every species and hybrid utilized by PNFI, with cross references to experiments. Anyone interested in further details concerning specific experiments or material should contact the Tree Genetics and Breeding Project at PNFI with the relevant experiment and/or seedlot numbers.

Larch species, both indigenous and exotic, have been exploited extensively throughout northern Europe and Asia for centuries. Rapid growth rates, favourable wood properties, and a high resistance to decay make larch very attractive for uses such as shipbuilding, construction, mining, and fencing (Schlich 1904). Larch has also been extensively used in northern Europe and the Soviet Union for pulp production (Kubes and Swan 1974), its high relative density compared with other conifers resulting in superior pulp yields. However, the high concentration of extractives, relative to other species, has been a major factor in the aversion of the North American forest industry to use of larch for pulp (Balatinecz 1983). In addition, the availability of tamarack (*Larix laricina* [Du Roi] K. Koch), one of the three larch species indigenous to North America, is limited due to its occurrence in small, isolated populations, despite having the largest range of any North American conifer (Roe 1957).

Larch species suffer from a variety of insect pests and pathogens. In North America the most significant pest is the larch sawfly (*Pristiphoria erichsonii* (Htg.)). In Europe larch canker (*Lachnellula willkomanii* (Hartig) Dennis) is a serious disease of European larch (*Larix decidua* Mill.) and has recently been reported in eastern North America. However, in recent years, with the emerging shortage of wood supplies, the fast growing and high density larches have evoked much interest as plantations species; this interest has evoked the possibility of genetic improvement (Morgenstern and Vallée 1986).

Improvement programs for different larch species are currently underway in Newfoundland, New Brunswick, Prince Edward Island, Quebec, and Ontario (Harrison 1988, Simpson 1983, Beaudoin et al. 1986, Hood et al. 1988).

ORIGIN AND DISTRIBUTION

Within the genus *Larix* Mill. 10 species are generally recognized (Dallimore and Jackson 1948). These species are distributed throughout the northern hemisphere. Taxonomists generally cannot agree upon the number of species because the larches are closely related and interspecific crosses are possible. "Races" of larches are often intermediate between two or more recognized species that are geographically adjacent, owing to extensive hybridization and introgression of adjacent races.

Of the 10 larch species three originate from North America, four from eastern Asia, two from the U.S.S.R., and one from Europe. Table 1 details the distribution of each species. Synonymy within the genus *Larix* is considerable and, for the purpose of this publication, only a partial reference list will be indicated for each species (Table 1).

Four of the species show a potential for commercial use in eastern Canada. They include European larch (*Larix decidua* Mill.), Japanese larch (*Larix leptolepis* [Sieb. and Zucc.] Gord.), Siberian larch (*Larix sibirica* Ledeb.), and tamarack (*Larix laricina* [Du Roi] K. Koch). In addition certain hybrids also show potential for use in eastern Canada.

Table 1. Species of the Genus *Larix*

	Species	Common name/s	Origin	Distribution Notes
1.	*L. laricina* (Du Roi) K. Koch	Tamarack Eastern larch	North America	Covers extensive area in northern North America. From central Alaska throughout central and eastern Canada to Newfoundland and into northeastern and north central United States. Grows in lowland areas at highest elevations to 500-600 m.
2.	*L. occidentalis* Nutt.	Western larch	North America	Elevations of 600-2200 m in Rocky Mountains of N. Idaho and eastern Washington, northern Oregon, western Montana, and southern British Columbia.
3.	*L. lyalli* Parl.	Alpine larch	North America	Elevations of 1200-3000 m in the Rocky Mountains of Alberta to eastern Montana and central Idaho; in northern Oregon, Washington, and southern British Columbia. Overlaps with Western larch but grows at higher elevations.
4.	*L. decidua* Mill. a) *L. decidua* var. *decidua* Mill.	European larch Alpine larch	Europe	Elevations of 300-2500 m throughout the Alps of southeastern France, northern Italy to northern Yugoslavia and Austria; also southeastern Switzerland and southern Germany.
	b) *L. decidua* var. *polonica* (Racib.) Ostenf and Larsen	Polish larch Slovakian larch Sudeten larch Tatra larch Carpathian larch		Elevations of 150-1500 m in the Carpathian mountains of Sudetenland and Slovakia in Czechoslovakia; lowlands of southern Poland and isolated areas in Romania and southeastern Ukraine.
5.	*L. leptolepis* (Sieb. and Zucc.) Gord.	Japanese larch	Japan	Interior of central Honshu on Mt. Fuji and other volcanic peaks; elevations of 1200 to 2750 m.
6.	*L. sibirica* Ledeb Syn: *L. sukacewii* Dylis	Siberian larch West Siberian larch	U.S.S.R	Lowlands of N.E. Russia and west Siberia; at elevations up to 1900 m in Ural mountains; in the south to Lake Baikal and northern Mongolia.
7.	*L. gmelini*	Dahurian larch	U.S.S.R. & Eastern Asia	Throughout lowlands of eastern Asia and West Siberia; south to Lake Baikal and eastern Mongolia north to north of Arctic Circle; in eastern Asia, mountains to 1800 m.
	a) *L. gmelini* var. *gmelini* (Rupr.) Kuzeneva	Dahurian larch East Siberian larch		
	b) *L. gmelini* var. *olgensis* (Henry) Ostenf. and Syn: Larsen *L. koreensis* Rafn.	Korean larch Olga Bay larch		Korea and along Sea of Japan – Olga Bay; along coasts of Siberia north of Vladivostok.
	c) *L. gmelini* var. *principis rupprechtii* (Magr) Pilger	North China larch Prince Rupprecht's larch		Isolated range in northern China in provinces of Shensi, Shonsi, and Chihli.
	d) *L. gmelini* var. *japonica* Syn: *L. kurilensis* Mayr.	Kurile larch Sakhalian larch		Isolated in Kurile Islands and Sakhalin, east of Siberia.
8.	*L. mastersiana* Rheder and Wilson	Master's larch	Eastern Asia	Elevations of 2100-3000 m in central China, province of Szechuan.
9.	*L. griffithiana* Hook	Himalyan larch Sikkim larch	Eastern Asia	Himalaya Range in Nepal, Bhutan, and Sikkim; also Chumbi Valley in Tibet, elevations ranging between 1700-3700 m.
10.	*L. potaninii* Batal	Chinese larch	Eastern Asia	Elevation of 2100-4800 m in central China province of Szechuan, Shensi, Yunnan and into eastern Tibet.

a) European larch

Röhrig (1980) recognizes three geographic races of *L. decidua*, namely "Alpine", "Tatra", and "Sudeten". "Alpine" larch occupies the region of the Alps from southeastern France and northeastern Italy to northern Yugoslavia and Austria. Within this area European larch grows at elevations between 300 and 2500 metres (Ostenfeld and Syrach-Larsen 1930, McComb 1955). "Tatra" larch is distributed in a small region of the Tatra Mountains and other parts of Slovakia in eastern Czechoslovakia at elevations between 500 and 1000 metres. "Sudeten" larch occurs in northern and northwestern Czechoslovakia and southern Poland at elevations between 300 and 1000 metres.

In addition to these three races with relatively small differences, Röhrig (1980) identifies the more distinctive "Polish" larch as a variety (*L. decidua* var. *polonica*) which occupies a large area in southern Poland at elevations between 150 and 500 metres. There are also six very small distribution areas in Rumania and the southwestern part of the Ukraine (Ostenfeld and Syrach-Larsen 1930). The distribution of European larch is shown in Map 1.

b) Japanese larch

Japanese larch has a small natural range located in the central portion of the island of Honshu (Map 2). The natural stands extend over an area of 200 km^2 and grow at elevations between 900 to 2500 metres (Farnsworth et al. 1972, Lee 1975). Distinct populations have developed due to the mountainous topography of the species range and strong environmental differences.

c) Siberian larch

Siberian larch has a natural range in northern and central U.S.S.R. (Map 2). Recent authors, including Arnborg and Eklund (1962) and Simak (1979), recognize two separate species, *L. sibirica* Ledeb. and *L. sukaczewii* Dyl. However, others consider these to be varieties of one species (Schoenike 1961, unpubl. manuscript; Simata 1964). In this report, "Siberian larch" is used to refer to both *L. sibirica* and *L. sukaczewii*. Its northern limit extends north of the Arctic circle, and its southern boundary goes down to Lake Baikal and northern Mongolia. This species grows at elevations of up to 2000 metres (Ostenfeld and Syrach-Larsen 1930).

d) Tamarack

Tamarack or Eastern larch is extensively distributed throughout North America (Map 3). In contrast to European and Japanese larch, it has a continuous distribution from Alaska to Newfoundland and the northern and northeastern United States (Roe 1957). Tamarack grows primarily in the lowlands, below 600 metres.

e) Hybrids

Intra- and interspecific hybridization is commonplace in the genus *Larix*. The best known hybrid is the "Dunkeld" larch. It originated near Dunkeld House, Perthshire, Scotland, and is a hybrid of Japanese and European larch. The hybrid was named *L. eurolepis* Henry and in many tests this F1 hybrid exceeded the parent species in growth by 10 to 20% (Syrach-Larsen 1937, 1956).

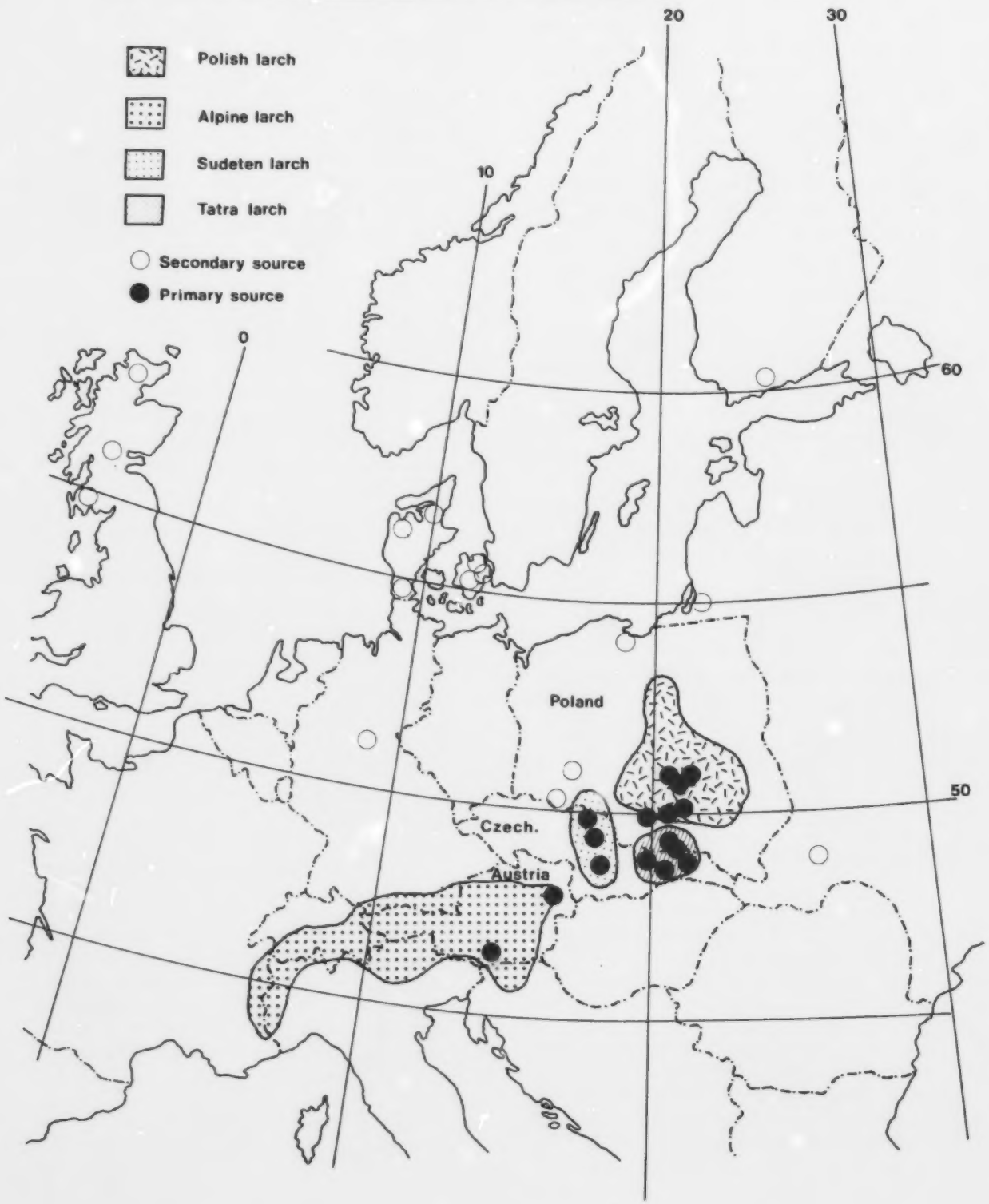
BACKGROUND OF LARCH BREEDING AT PNFI

Larch was introduced to PNFI in 1926. At that time, seed was obtained from a Japanese larch plantation in Dunkeld, Scotland. This plantation, however, was situated close to a European larch plantation and, as a result, the material included European x Japanese hybrids, the well-known "Dunkeld" larch. Seed was sown in 1926 and a plantation established at PNFI in 1928. This is believed to be the first planting of the "Dunkeld" larch in North America.

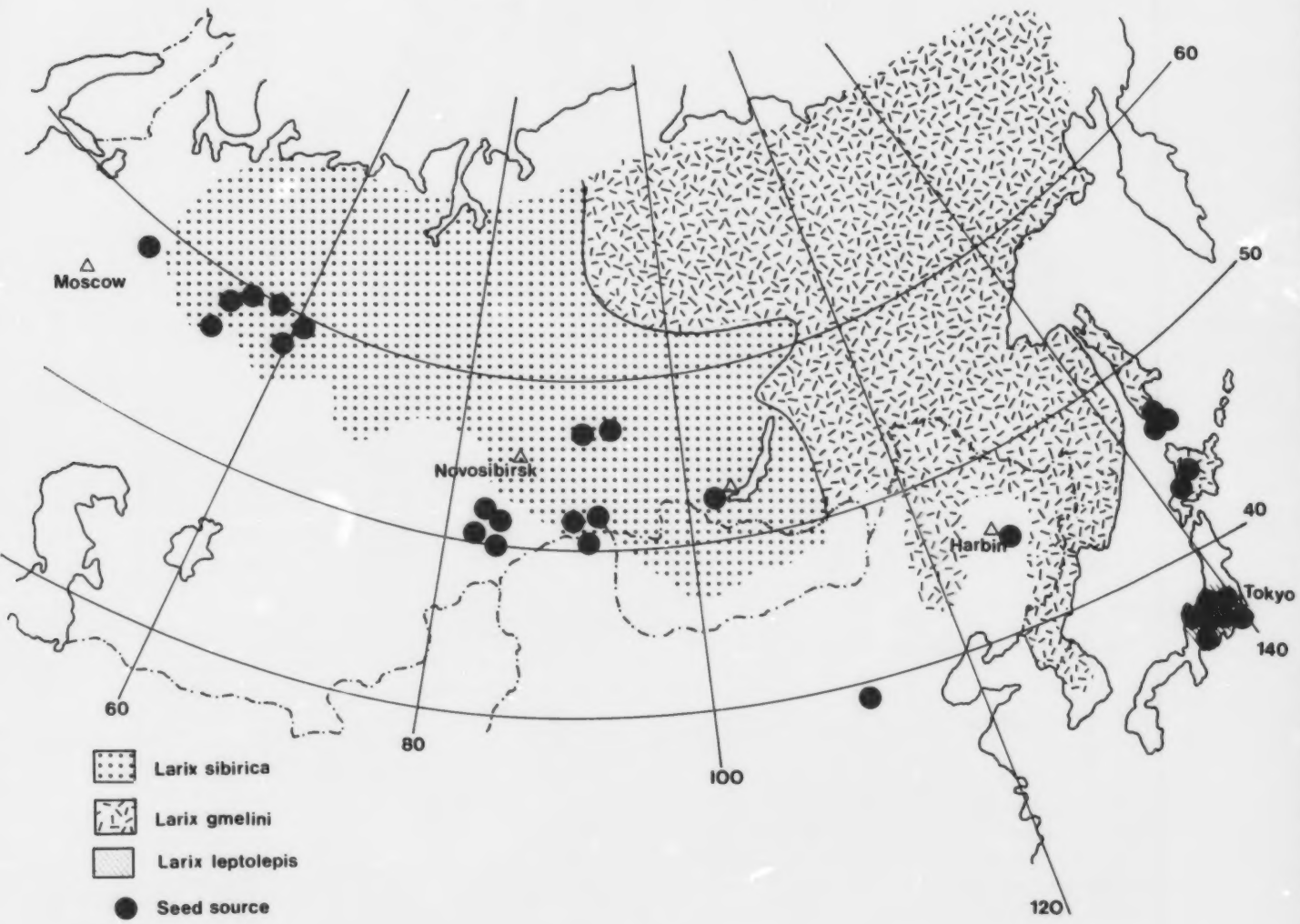
Until the 1950s work on larch species was only intermittent but, over the following 20 years, a total of 350 seedlots of various larch species and hybrids were established in plantations at PNFI. Twenty eight series of experiments have been initiated at PNFI since 1926. Through cooperative efforts seed has been exchanged with various national and international forestry agencies, and experimental plantations established across Canada and the United States.

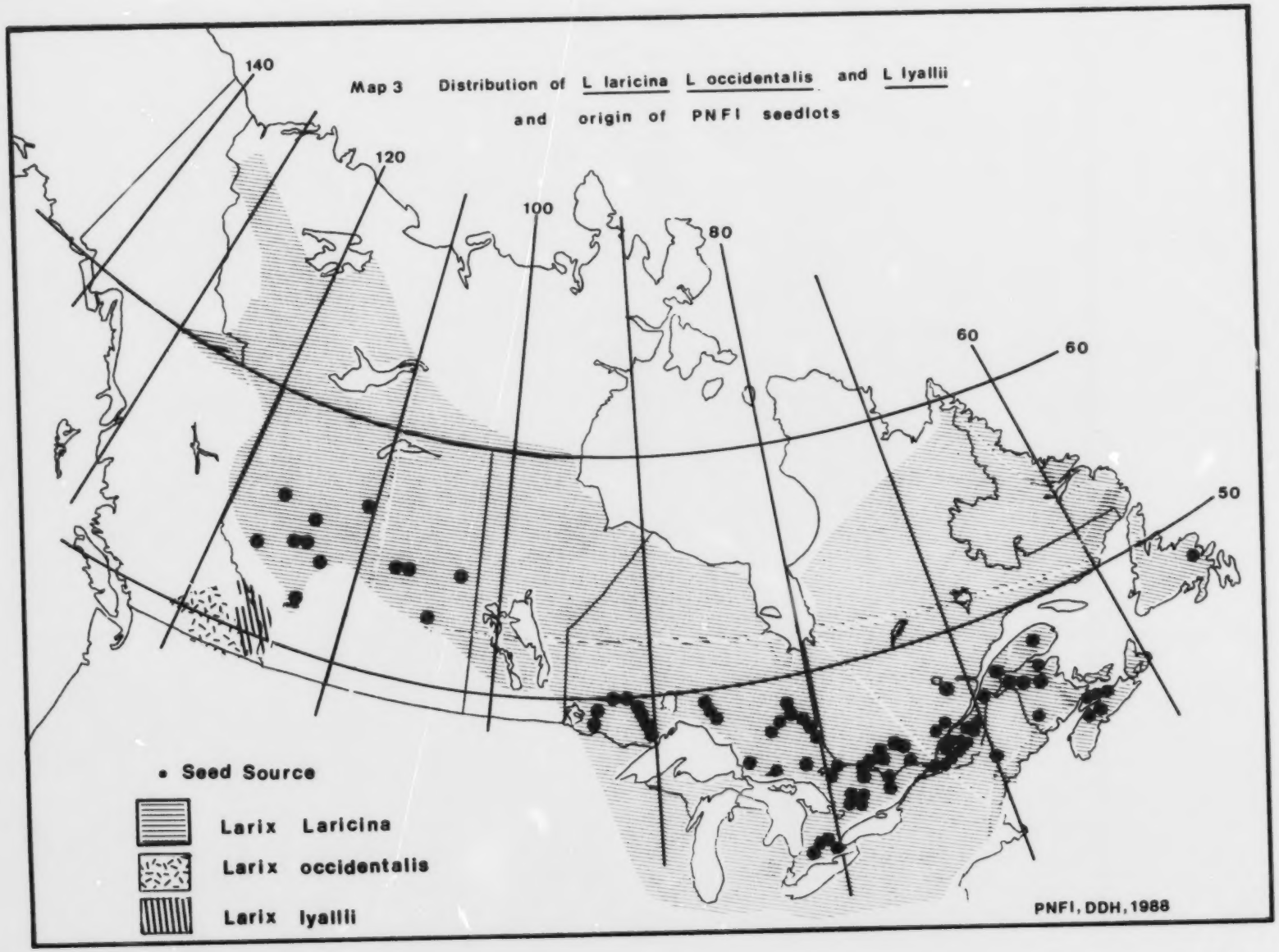
Planting designs varied considerably and were dependant on the number of seedlots, their

Map 1 Distribution of L. decidua and origin of PNFI seedlots



Map 2. Distribution of L. sibirica, L. gmelini and L. leptolepis and origin of PNFI seedlots




Map 3 Distribution of L laricina L occidentalis and L lyallii
and origin of PNFI seedlots
140
120
100
80
60
60
50
• Seed Source
Larix Laricina
Larix occidentalis
Larix lyallii
PNFI, DDH, 1988

origin, and the quantity of seedlings. Although several early experiments were randomized and replicated, some were planted out simply as unreplicated plots. As the early plantations matured, controlled hybridization work was initiated. In the early 1970s, 49 control-pollinated hybrids were created involving *L. decidua*, *L. sibirica*, *L. occidentalis*, *L. laricina*, *L. leptolepis*, and *L. gmelini*. This material is represented in several plantations at PNFI and elsewhere.

Recently, 599 tamarack seedlots from across the species' range have been accumulated at PNFI. This seed was acquired with the cooperation of many forestry agencies in Canada and the U.S. The first range-wide provenance trials of this material were planted at PNFI and in northern Ontario in 1986-87. Further provenance and progeny tests of this material have been established in Ontario, Quebec, New Brunswick, and Newfoundland.

RESULTS AND DISCUSSION

1) European larch

There are 71 seedlots of European larch represented in experiments at PNFI and, of these, at least 47 are from secondary sources, mostly via Denmark and Scotland and from plantations of other seedlots at PNFI. Of the primary sources, Map 1 indicates a fairly intensive sampling of "Tatra" larch and of parts of the range of "Polish" larch, with fewer samples of "Sudeten" larch and only two primary sources from the extensive range of "Alpine" larch. This tends to reflect provenance results from Europe and North America (e.g. Giertych 1979, Vyskot 1967, Lines 1967, Barnes 1977) which show that "Alpine" larch is the least vigorous of the European larch races outside its natural range, particularly at low elevations.

There are a substantial number of provenance experiments with European larch at PNFI. The earliest were the 35 series (Fig. 1), sown in 1949, containing eight secondary sources and one primary "Sudeten" source. Subsequently, experiments 90-A and the 202, 209, and 252 series have all included a comparison of European larch provenances, at least as a component of the experimental design. Several of these experiments also included open-pollinated families, but the only experiments specifically designed as open-pollinated progeny tests have been 381-B-1 and 381-B-3. Seedlots have also been included in some experiments, notably 381-B-2, 381-A-2, and 381-A-3 (see below under Larch hybrids). However, none have been designed with a planned relationship that allows estimation of the genetic parameters.

Fig. 1 Experiment 35: European larch provenances and species comparison, age 38 years.

a) Primary provenance samples

The single primary source in Exp. 35-A, from the Sudeten region, was the tallest seedlot at age 30 in 1979, although some of the Danish open-pollinated seedlots had a larger diameter. Of the four primary sources in Exp. 90-A, the two "Polish" provenances were far superior to the two Austrian provenances at ages 12 and 28, both for height and diameter (see table in Appendix II).

The 202 series consists of 12 experiments planted throughout eastern Canada and in New York state, involving species comparisons and

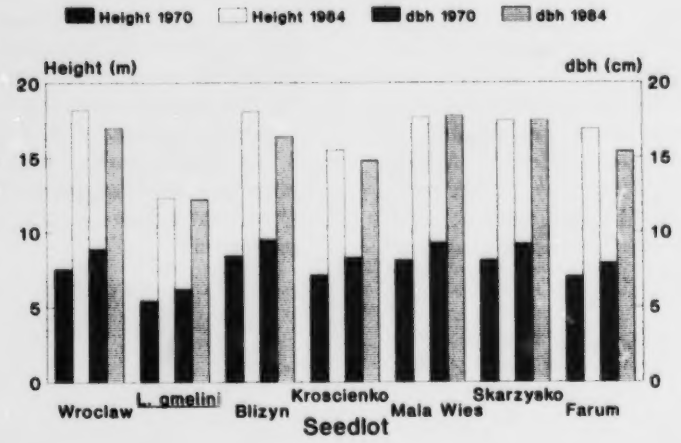


Fig 2a. Height and diameter data from the 202 series of European larch provenance tests.

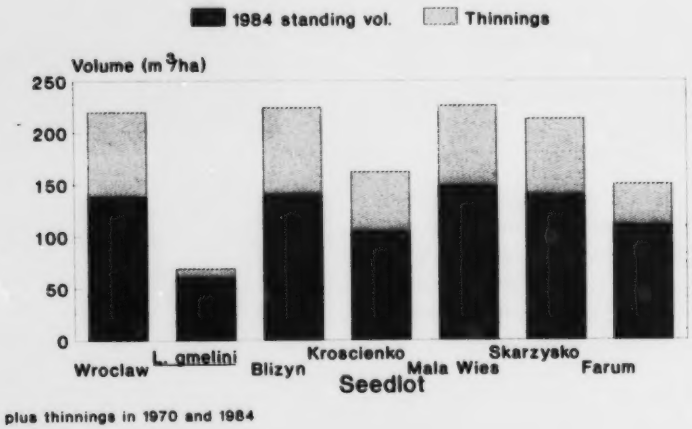


Fig. 2b. Volume at 28 years, Expt. 202-A.

Table 2. Height and diameter growth and 1966 survival in experiment 202-A (heights in m; diameters in cm; survival in %).

Seedlot	Origin	Ht66	Surv	Ht70	D70	Ht77	D77	Ht84	D84
2316	Wroclaw, Poland	3.8	87	7.7	8.9	13.2	14.1	17.9	17.0
2372	*L. gmelini*	2.9	45	5.7	6.2	9.3	9.8	12.8	12.2
2498	Blizyn, Poland	4.6	96	8.5	9.6	13.1	13.9	18.0	16.5
2499	Kroscienko	3.6	93	7.2	8.3	11.5	12.6	15.6	14.9
2500	Mala Wies. Poland	4.2	90	8.1	9.4	12.9	14.7	17.6	17.9
2501	Skarzysko, Poland	4.2	89	8.2	9.3	13.4	14.5	17.5	17.5
2502	Farum, Denmark	3.3	92	7.0	7.9	12.4	12.9	17.0	15.4

several provenances of European larch. Two of the series were planted at PNFI, but only one of these (202-A) was replicated. The European larch in this test consists of five Polish provenances and one secondary source from Denmark. Although the sources from Poland are believed to be primary, several are located in areas where larch has been extensively planted, and the possibility exists that the seed was collected from plantations. Heights and diameters were recorded at several ages, most recently at age 28 in 1984 (Fig. 2a, Table 2), and the plantation was thinned in 1970 and 1979. Based on the 1979 thinning yields, the volume per hectare of the standing crop was estimated (Fig. 2b). The Blizyn source was consistently among the tallest and, in early assessments, also had the largest diameter. By 1984, however, the average diameter of both Mala Wies and Skarzysko exceeded that of Blizyn before thinning. In terms of estimated volume per hectare, Mala Wies was the most productive (148 m^3/ha after thinning, 224 m^3/ha total production), followed by Blizyn (140 m^3/ha, 224 m^3/ha total production) and Skarzysko (138 m^3/ha, 212 m^3/ha total production). Measurements in 1982 in the unreplicated 202-J indicated a similar result, with Blizyn the tallest provenance but Mala Wies and Skarzysko having larger diameters. Assessments of sawfly defoliation in 1977 in experiment 202-A revealed significant differences among seed sources ($P<0.05$). Skarzysko, Blizyn, and Wroclaw sources were the most susceptible, Mala Wies and Kroscienko were intermediate, and a secondary source via Farum, Denmark was least susceptible.

An interesting aspect of the samples in experiment 202-A is the fact that, although all primary sources are from Poland, they represent two races of *L. decidua* plus *L. decidua* var. *polonica*. Three (Blizyn, Mala Wies, and Skarzysko) are "Polish" larch (*L. decidua* var *polonica*), one (Wroclaw) is "Sudeten" from south of Wroclaw and one (Kroscienko) is "Tatra" larch. By 1984, although there were no significant differences among the "Polish" and "Sudeten" provenances, they were significantly taller than the "Tatra" larch ($P<0.05$) and had a significantly larger diameter ($P<0.05$). There are no significant differences among any of the provenances in terms of survival, all having a survival greater than or equal to 90% at age 4. The age-to-age correlations for height in 202-A over the four assessment ages (10, 14, 21, and 28) were consistently greater than 0.8, indicating high rank stability.

In another experiment of the same series, 202-G-1, planted at Grenville, Quebec, Blizyn was again the tallest provenance at age 21, and Wroclaw ranked fourth, but there were no significant differences among provenances. Ten years earlier, an assessment of stem form had indicated that the "Sudeten" provenance (Wroclaw) was superior to the "Tatra" provenance (Kroscienko), which in turn was superior to the three "Polish" provenances. The secondary source via Farum, Denmark was, however, better than any primary source.

The 209 series is similar to the 202 series in that it consists of 10 experiments planted in eastern Canada and contains a variety of material. Of the 10 experiments, five are planted on diverse sites at PNFI and two more on Canadian International Paper. Inc. (CIP) land at Harrington, in western Quebec. The primary sources of European larch are common to most of these experiments, and consist of only two provenances: Rosalia, Austria and Muszyna, Poland. Heights at several ages are shown in Table 3 for experiments from the series and in Fig. 3, for age 21 (1979). Of the two primary sources, Muszyna was far superior to Rosalia at all ages and over all sites, not only for height, but for diameter and volume growth as well. In 1977, defoliation by sawfly occurred on all seed sources in 209-A at PNFI. Defoliation was significantly correlated with height in this experiment ($P<0.05$), but the Farum, Denmark source, as well as being among the tallest, was also one of the least defoliated.

The final experiment containing a significant number of primary sources of European larch is 252-A, established at PNFI in 1962 and consisting of seven Czechoslovakian provenances plus two secondary sources. Heights were recorded at ages 6 and 14 and, in 1983, at age 21, the plantation was thinned, heights and diameters recorded, and volume per hectare estimated based on thinning yields (Table 4). In terms of both height and diameter, Krnov Radin was the best provenance in 1983, with an estimated volume of 145 m^3/ha (before thinning). Cierny Vah had the smallest diameter and was shortest, with an estimated 85 m^3/ha. Three of the provenances (Krnov Radin, Parsovice, and Trencin) are of the

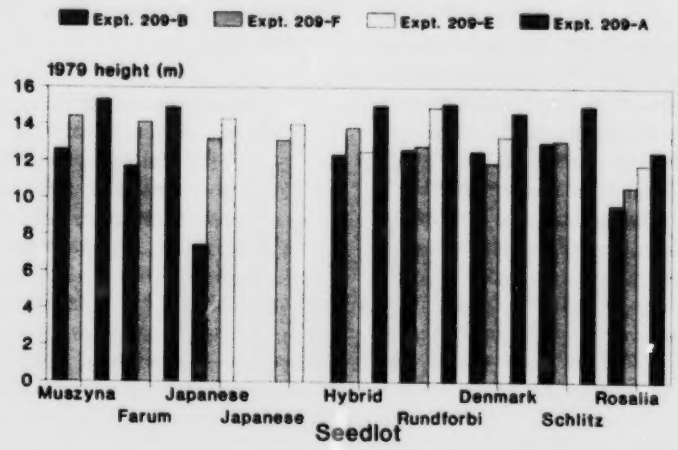


Fig. 3. Height data from the 209 series of European larch provenance tests.

Table 3. Height growth in the 209 series (metres).

Seedlot	Origin	Ht66	Ht79	Ht67	Ht79	Ht66	Ht79	Ht66	Ht79
		209a		209b		209e		209f	
1886	Rosalia, Austria	2.7	12.5	1.7	9.6	2.6	11.8	1.8	10.6
1887	Paternion, Austria			1.4	8.4				
2145	Muszyna, Poland	4.0	15.3	2.6	12.6			2.7	14.4
2502	Farum, Denmark	3.9	14.9	2.3	11.7			2.8	14.1
2522	*L. leptolepis*			1.5	7.4	3.7	14.3	3.0	13.2
2523	*L. leptolepis*					3.8	14.0	2.9	13.1
2524	*L. eurolepis*	4.2	15.0	2.3	12.3	4.2	12.5	3.1	13.8
2525	Rundforbi, Den.	4.4	15.1	2.5	12.6	4.0	14.9	2.5	12.8
2526	Denmark	3.8	14.6	2.7	12.5	3.5	13.3	2.7	11.9
2527	Schlitz, FRG	4.0	15.0	2.6	13.0			2.8	13.1

Note: 209-A, E, and F are located at PNFI, 209b at Harrington, Quebec. Survival of 2522 and 2544 very low at 209-B (~10%).

Table 4. Heights (m) and diameters (cm) in experiment 252a.

Seedlot	Origin	Ht76	Ht83	Dbh83
2655	Farum, Denmark	7.0^{a}	11.1^{abc}	10.7^{a}
2656	Farum, Denmark	6.6^{ab}	10.5^{bc}	10.0^{ab}
2845	Sabinov, Czech.*	6.8^{ab}	10.9^{bc}	10.4^{ab}
2846	Krnov Radin, Czech.**	7.3^{a}	11.7^{a}	10.6^{a}
2847	Parsovice, Czech.**	6.9^{ab}	10.9^{abc}	10.2^{ab}
2848	Trencin, Czech.**	6.9^{ab}	11.2^{ab}	10.1^{ab}
2849	Tatranska, Czech.*	6.7^{ab}	10.9^{abc}	9.3^{ab}
2850	Cierny Vah, Czech.*	6.2^{b}	10.0^{c}	8.9^{b}
2851	Cervena Skala, Czech.*	6.6^{ab}	10.8^{abc}	9.6^{ab}

Note: ** "Sudeten" provenance; * "Tatra" provenance
Letters indicate homogeneous groups at the 5% significance level, according to Bonferroni's t-tests

"Sudeten" race of European larch, while the other four are "Tatra" larch. A direct comparison of the performance of the two races indicated the the "Sudeten" sources were very significantly taller than the "Tatra" sources, both in 1976 and 1983 ($P<0.01$), but there was no significant difference in terms of diameter.

b) Secondary sources

All of the experiments discussed in relation to primary sources also contain secondary sources of the species that have mostly been obtained via Denmark or Scotland. In many cases the original source of the material is uncertain and, even when it is known, the paternal parentage is usually not known. This makes interpretation of the data quite difficult.

In the 202 series, only one secondary source was represented, of Alpine origin, via Farum, Denmark. Although consistently shorter than the best Polish provenances, and having a smaller diameter (Table 2), it performed very similarly to the only "Tatra" provenance (Kroscienko) and had actually exceeded it by 1984 in terms of stand volume. Its diameter was significantly smaller than the "Polish" and "Sudeten" provenances ($P<0.05$), but there were no significant differences in terms of height.

Four secondary sources are represented in the 209 series (Table 3). Of these, two are of "Alpine" origin, one (S. 2502) having undergone at least four generations of selection in Denmark, and the other (S. 2527) having been managed at Schlitz, West Germany for several generations. The third source is of "Polish" larch (S. 2526), via a Danish seed orchard and the fourth (S.2502), also via Denmark, is of suspected "Sudeten" origin. Across several tests in the 209 series, some consistent features are evident. Firstly, none of the secondary sources exceed the better primary source (Muszyna) in terms of height, but larger diameters result in equal or larger volumes at age 27. Secondly, the secondary "Alpine" sources are vastly superior to the primary "Alpine" source (Rosalia). In 209-A the respective heights and volumes after thinning at age 27 are: 18.0 m and 175 m^3/ha (S. 2527), 17.0 m and 168 m^3/ha (S. 2502), and 14.6 m and 111 m^3/ha (Rosalia). Similarly, in 209-F-2, the average volume per tree at age 21 for S. 2527 was 0.093 m^3, while for Rosalia it was only 0.028 m^3. Pearson product-moment correlation coefficients for height growth among sites were significant at the 1% level for 209-A and B, and at the 5% level for 209-A and F in 1979. Other comparisons were non-signficant, but this was partially due to small common sample sizes and, in some cases, differential survival.

Experiment 252-A contains two secondary sources, one (S. 2655) of "Alpine" origin and the other (S. 2656) of unknown origin. Of these two, S. 2655 is comparable to the "Sudeten" provenances, both in terms of diameter and height, whereas S. 2656 has performed very similarly to the "Tatra" sources.

c) Open-pollinated progeny test

Experiment 381-B-1 consists of eight open-pollinated families of "Alpine" origin, via Denmark and other plantations at PNFI. The field trial was established as six replications of 10-tree row plots in1976. In 1987, at age 15 years from seed, heights and diameters were recorded, together with stem form and damage characters in the three replications having adequate survival. Analyses of variance indicated no significant differences among families either for diameter or height growth. Estimates of individual-tree heritabilities for height and diameter were 0.02 and 0.18, respectively. Family heritabilities were 0.09 and 0.48, respectively. Survival in the three replicates assessed was excellent, the low survival in the other three being due to the experiment being planted on a highly diverse site. Similarly, form and damage defects occurred at such a low level as to make analysis pointless.

Discussion of European larch experiments

Despite the lack of a comprehensive provenance experiment and the small sample sizes involved, several features are clearly illustrated by this array of European larch experiments. Firstly, it is clear that "Polish" and "Sudeten" provenances are often superior in growth rate to "Tatra" sources and greatly superior to "Alpine" sources. This marked difference between "Alpine" and other races of European larch has been a consistent result in provenance tests in many countries (e.g. Genys 1960, Jeffers and Isebrands 1974, Tulstrup 1950, Schober 1985,

Miller and Thulin 1967, Sindelár 1983). In most cases, however, the "Tatra" larch is found to be comparable to the "Sudeten" and "Polish" larches in growth rate (e.g. Miller and Thulin 1967, Tulstrup 1950, Schober 1985). Because the PNFI experiments contain a fairly intensive sample of "Tatra" larch, it is unlikely that inadequate sampling would explain the apparent inferiority of "Tatra" larch in this case. Some "Tatra" provenances are as productive as "Sudeten" and "Polish" larch, indicating substantial provenance variation. No consistent pattern of variation or causal explanation is apparent, however.

Another frequent result of provenance testing in European larch is a marked variability in stem form among the different races. Tulstrup (1950) and Schober (1985) both report that "Tatra" larch generally exhibits superior stem form, whilst "Sudeten" and "Polish" provenances are, with some exceptions, average to poor and "Alpine" sources are often very crooked. "Sudeten" larch in particular seems to be very susceptible to basal sweep. Although no quantitative data suitable for analysis has been collected from provenance tests at PNFI, a subjective assessment of provenance variation tends to confirm this general pattern. In the 209 series, however, the seedlot from the Tatra mountains (Muszyna), although the tallest of the European larch seedlots, also had the worst basal sweep and overall stem form. The combined effect of growth rate and stem form led Schober (1985), evaluating 26 IUFRO provenance experiments in the USA and throughout Europe, to recommend "Tatra" larch, particularly provenances from high elevations, as the most suitable for afforestation. In a review of Czechoslovakia data from the 1958-59 IUFRO provenance test series, Sindelár (1983) reported that "Sudeten" sources were the fastest growing, but suffered from having only an average stem form. Slower-growing provenances from the Alpine regions and Rumania exhibited superior stem form, and "Tatra" sources combined superior form with better-than-average growth. He, therefore, recommended planting of "Sudeten" sources at low elevations, with selection for stem form emphasized in breeding programs, and the use of "Tatra" seedlots at higher elevations.

But it is clear that stem form can be easily improved through selection. Many of the secondary sources from "Polish", "Sudeten", and "Alpine" origins exhibit stem form that is greatly superior to primary provenances, having undergone one or more generations of selection. In the 209 series, a "Polish" source via Denmark has good stem form and a secondary "Sudeten" source is markedly superior to the primary "Tatra" provenance in the same tests. Again, an "Alpine" source via Denmark has good stem form and a greatly improved growth rate compared with the primary "Alpine" source in the same tests. The source from Schlitz, West Germany is another "Alpine" source that has passed through several generations of management. As a result, it is the second tallest seedlot in the 209 series (compared to the "Sudeten" provenance) and has the largest average volume per tree. These results are the same as were found by Schober (1985) for this source, in that the height growth of Schlitz was surpassed only by "Tatra" sources over the 26 IUFRO tests, but Schlitz had the best volume growth. In both the IUFRO tests and the PNFI experiments, however, this source exhibited the poor stem form that is characteristic of primary "Alpine" sources.

A major problem with European larch in Europe is its susceptibility to larch canker (*Lachnellula willkomii* [Hartig] Dennis). Observations of European tests suffering from larch canker have indicated that the incidence of canker on "Alpine" sources is three to five times as frequent as on all other sources (Schober 1985). Although the canker is currently only present locally in parts of eastern Canada (Canadian Forestry Service 1987), any consideration of European larch for afforestation must take account of the possibility of canker. Unselected "Alpine" sources should be avoided for this reason.

In provenance selection of European larch for Ontario and western Quebec, the ideal choice would be a secondary source of "Sudeten" or "Polish" origin that has undergone some selection for stem form. Primary provenance samples should preferably originate either from a "Sudeten" or "Polish" source having above average stem form, or from a high yielding "Tatra" source. Tulstrup (1950) mentions Skarzysko as an example of the former. In experiment 202-A, this provenance was the tallest at age 28 and ranked third in terms of volume. At age 10, a subjective assessment of stem form indicated that the Skarzysko source was markedly better than

the other primary sources and was inferior only to the secondary "Alpine" source that had undergone several generations of selection. Based on an earlier assessment of the 202 and 209 series, Teich and Holst (1973) also recommended the Zagnansk provenance as combining both superior growth rate and satisfactory stem form. The alternative, a high-yielding "Tatra" source, is best represented in PNFI tests by Muszyna, Sabinov, and Tatranska which were shorter in experiment 252-A than the three "Sudeten" sources (but not significantly). The estimated volume per hectare for Sabinov was second only to the best of the "Sudeten" sources, Krnov Radin (145 m^3/ha vs 139 m^3/ha).

The low estimates of single-tree and family heritabilities estimated from experiment 381-B-1 for height growth indicate a low potential for genetic improvement for this trait. Part of the reason for this is that the material has already undergone several generations of selection, as indicated by the very low frequency of stem defects. In addition, the possibly limited size of the original base population may have contributed to the low level of genetic variation of this trait. Narrow-sense heritability for height at age 9 years, based on progenies of an incomplete diallel cross in Czechoslovakia, was estimated at 0.2 (Sindelár 1986). In the same study, estimated heritabilities for diameter at ages 9 and 16 were 0.5 and 0.24, respectively, and for 9-year stem form 0.42. Other results cited by Sindelár (1986) include estimates of heritabilities for height, diameter, and stem form at age 9 of 0.16, 0.04, and 0.37, respectively (Gracan 1973), compared with higher estimates obtained by Haasemann (1972) at age 7 of 0.62 for height and 0.57 for stem form. These values were obtained from material that had undergone only limited selection or none at all. Few other studies have estimated heritabilities for height growth in European larch, but an analysis of a diallel cross involving Japanese and reciprocal Japanese x European hybrids by Matthews et al. (1960) estimated heritability for height ranging from 0.08 to 0.14 for the hybrid material and for diameter ranging from 0.01 to 0.1.

2) Japanese larch

Most *L. leptolepis* seedlots represented in PNFI experiments come from secondary sources – at least 79 out of a total of 101. For many of the secondary sources, the original source is unknown. Japanese larch is only represented in three replicated experiments in any quantity (375-A, 378-A, and 428), the last of these being a series of mass-selection plantations and associated open-pollinated family tests recently established in southeastern Ontario. These tests contain 42 seedlots from a single plantation in Japan, which provides an opportunity to estimate the genetic parameters for a single population. There have been no other replicated experiments established containing progenies with a designed relationship such that estimates of genetic parameters can be made.

a) Primary provenance samples

Experiment 375-A is a provenance test of Japanese larch, in which six primary provenance samples, together with two secondary sources, are represented in 10 replications of 10-tree row plots. Although only apparently hardy plants were selected in the nursery beds for field planting, all seedlots suffered from moderate frost damage the following spring, with no significant differences among seedlots. At age 15 (from seed), there were no significant differences among seedlots in terms of height, which was an average 6.84 m with a range of 6.0 m to 7.8 m (Table 5). However, in seven of the 10 replications, survival was so patchy, with no obvious relation to seedlot, that no assessment was made. In the other three replications, survival averaged only 55%. The tallest seedlot (Sekigawa, Japan) had a survival rate of only 43%, whilst the seedlot with the highest survival was also the shortest (Mizunoto, Guma, Japan).

b) Secondary sources

The two secondary sources in experiment 375-A (via Scotland) ranked second and third for 15-year height, but survival was less than 50%. In experiment 378-A, a trial of European and Japanese larch and their hybrids, four secondary sources via various European nations had good survival but poor growth rates and stem form, with little variation among the four seedlots.

The 79 seedlots included in three replicated experiments of the 428 series represent a wide diversity of material, from original provenance samples to seed orchard bulk collections and

clones. In 1980, three years after planting, there were significant differences among seedlots at each site and over all sites, both in terms of survival and height growth. For both traits, seedlot x site interaction was also highly significant. This can be emphatically illustrated by considering the performance of seedlot 7280, from Morayshire, Scotland (Table 6). In experiment 428-E-1 (Brockville, Ont.) it suffered the greatest mortality of any seedlot (40% survival), whilst in experiment 428-E-2 (Kemptville, Ont.) it had the third highest survival (95%). In terms of height growth, this seedlot was the slowest growing in 428-E-1, although it was planted in only two replications and does not, therefore, appear in Table 6. In contrast, in 428-G-1 (Batiscan, Que.), it was second tallest (2.76 m). In 1986, differences among seedlots in the two Ontario experiments were still significant (Schnekenburger and Yeatman 1988).

Two seedlots of Japanese larch via Denmark were also included in several of the 209 series of experiments. In two trials planted at Harrington, Quebec, the Japanese larch was all but wiped out; less than 10% survived. In two more locations at PNFI, sawfly defoliation was light and survival was satisfactory although growth rates were very slow.

c) Open-pollinated family tests

As noted previously, a subset of the seedlots represented in the 428 series constitute 42 open-pollinated seedlots from a single population in Japan. Analysis of eight-year height data for these families yielded an estimate of 0.30 for family repeatability. In contrast to the full complement of seedlots, site x family interaction for these families was insignificant, amounting to only 0.4% of the total phenotypic variation.

Discussion of Japanese larch experiments

The poor survival of all seedlots in experiment 375-A reflects a commonly observed phenomenon among Japanese larch provenances in North America. Pauley et al. (1965) reported 45% mortality four years from planting at two sites in Minnesota, compared with only 15% mortality for European larch. Reporting results from 17 plantations in the same series of provenance trials, Farnsworth et al. (1972) noted that mortality ranged from 4% to 86%, two years after planting but, during the next five years, substantial additional mortality occurred in only a few cases. In Maryland, mortality ranged from 33% in a lowland plantation to 51% on the Piedmont plateau after five years and, in the latter experiment, differences among provenances were significant (Genys 1971). Similarly, in a species trial in Newfoundland, Hall (1984) reported only 43% survival for Japanese larch after eight growing seasons. In contrast, Park and Fowler (1983) reported a 19-year survival rate of 83%, averaged over 20 provenances. Six years later survival had dropped to 79%, but this was still superior to tamarack and European larch (Fowler et al. 1988).

Differences in height growth among provenances have been previously found to be significant, but the absolute magnitude of such differences is often not great and no geographic pattern has been discerned. For example, in the Minnesota tests, part of the "NC-51" seven-provenance series, although significant differences in four-year height were detected, the high

Table 5. Results of experiment 375-A (heights in m; diameters in cm; survival in %).

Seedlot	Origin	Height age 10	Height age 15	Diameter age 15	Survival age 15
6689	Honshu	1.7	6.1	6.3	30
6843	Kumashiro Yama	2.6	6.8	7.5	70
6844	Mizunoto	2.6	6.1	6.6	87
6845	Yashuhara	2.6	6.9	8.1	70
7290	via Scotland	2.4	7.3	8.5	40
7291	via Scotland	3.3	7.1	8.3	53
7307	Sekigawa	2.7	7.6	9.2	43
7309	Kamikawa	2.2	6.7	7.0	53

Table 6. **Height growth (top 10 and bottom 10) of Japanese larch seed sources in series 428 and survival of those sources, age 5 (1983). Unless otherwise indicated, all listed seed sources are present at all sites – a blank space indicates that it was not among the best or worst 10 seedlots. Underlined seedlot appears in both groups.**

		Expt. 428e1		Expt. 428e2		Expt. 428g1	
Seedlot	Origin	Ht. (m)	Surv. (%)	Ht. (m)	Surv. (%)	Ht. (m)	Surv. (%)
7278	Sostrup, Denmark	2.2	68	2.0	87	2.7	98
7280	Morayshire, Scotland			2.3	95	2.7	95
7290	Ross-shire, Scotland	2.2	80	Not present			
7292	Yatsugata			2.2	92		
7794	Flensborg, Denmark			2.0	91	2.8	99
8902	Tokachi	2.2	80				
8904	Tokachi	2.1	78				
8907	Tokachi					2.7	90
8915	Tokachi			1.9	92		
8921	Tokachi	2.2	84				
8924	Tokachi	2.4	62	1.9	83	2.6	94
8925	Tokachi			2.0	89		
8927	Tokachi			1.9	81	2.7	94
8928	Tokachi	2.1	78				
8929	Tokachi					2.7	97
8932	Tokachi	2.2	90	Not Present			
8934	Tokachi			1.9	90	2.7	96
8936	Tokachi					2.6	97
8938	Tokachi	2.2	82				
8939	Tokachi	2.1	70				
8947	Tokachi			2.0	81		
8957	Gavnø, Denmark					2.6	97
7267	Finland	1.6	46	Not present			
7279	Morayshire, Scotland					2.2	86
7291	Kirkudbright, Scotland					2.1	89
7304	German Dem. Rep.			1.5	87	2.2	87
7478	Feldborg, Denmark			1.4	81		
7481	Hondo					2.2	96
7483	Dejbjerg, Denmark	1.8	56				
7490	Harrington Farm, Qué.			1.4	78	2.1	92
8911	Tokachi			1.5	86		
8912	Tokachi	1.7	78	Not present			
8917	Tokachi	1.8	58	Not present			
8919	Tokachi	1.8	72				
8922	Tokachi			1.4	82		
8925	Tokachi	1.7	64				
8935	Tokachi	1.7	74				
8941	Tokachi	1.8	68				
8945	Tokachi			1.4	80		
8950	Tokachi	1.6	44			Not present	
8952	Hokkaido					2.2	89
8953	Nagano			1.4	73	2.2	91
8954	Kumashiroyama			1.4	77	2.0	88
8955	Mizunoto			1.3	79	2.1	87
8961	Nagano	1.4	60	1.2	75	2.2	95

mortality precluded analysis according to the original design, and a means separation test indicated that only the shortest provenance could not be included in a single homogeneous grouping (Pauley et al. 1965).

In 1957, W. Langer initiated a large-scale provenance testing program for Japanese larch, including 25 provenances, planted at many sites in Europe, North America, and Japan. In most of these tests, including those in Canada, the United States, and Germany, significant differences among provenances were found for height growth, but provenance x site interactions were also very significant (Hattemer 1974, Farnsworth et al. 1972, Genys 1971, Park and Fowler 1988, Fowler et al. 1988). This led to the conclusion that there was no predictable pattern for geographic variation in Japanese larch and that differences among populations could be best attributed to random drift (Farnsworth et al. 1972, Park and Fowler 1983). In an analysis of specific gravity of the same material planted at Fredericton, New

Brunswick, Loo et al. (1982) arrived at the same conclusion, finding significant differences among provenances, but also significant provenance x replication interaction and no obvious geographic pattern of differences.

In experiment 428 highly significant differences were found among seedlots, although this is only to be expected given the diverse nature of the material. The highly significant seedlot x site interaction for both survival and height growth is consistent with previous results. Schnekenburger and Yeatman (1988) reported on five-year results for two of the tests located in eastern Ontario. Not surprisingly, they were very similar to the eight-year results reported here. The estimate of family repeatability for height growth (0.30) is fairly typical, although somewhat lower than those estimated for other conifer species. However, because this estimate was obtained from families representing a single population, it should be taken as only an indication of family repeatability for the species as a whole.

In the PNFI provenance experiment (375-A) no significant differences were found among seed sources; this is possibly a reflection of the limited sample. On the other hand, even in some large-scale provenance trials, differences among provenances have been found to fluctuate between significance and non-significance at different ages (Robak 1982). In view of the rather small magnitude of provenance differences and the absence of a predictable pattern, it would not, therefore, seem worthwhile to attempt provenance selection in the initial stages of a tree improvement program for Japanese larch. Hattemer (1974) made the same recommendation, based on an analysis of a larch progeny test and, furthermore, suggested that hybrid breeding is the best approach to tree improvement in larch. Based on data from species comparison tests in the Maritime provinces, Fowler (1987) also recommended hybrid breeding, with vegetative propagation of the resulting seedlings as the most suitable approach for breeding *Larix* spp. The low survival of Japanese larch seedlots at PNFI and elsewhere would indicate that initial efforts in North American conditions should concentrate on identifying hardy families or individuals. Again, hybridization with European larch would be a simple and effective method of improving winter hardiness in larch.

3) Hybrid larch

Hybrid larch can be considered under two sub-headings: (a) Japanese x European hybrids (*L. eurolepis* Henry) and (b) all other hybrids. There is one replicated experiment for each of these two groups at PNFI that is designed specifically to study variation and performance of the hybrids, though individual seedlots were often included in other tests (considered under the "Special comparison" section). Several other unreplicated tests exist in the Petawawa Research Forest.

a) *L. eurolepis*

Experiment 378-A consists of nine seedlots from hybrid seed orchards in Denmark, the German Democratic Republic, and Sweden, together with seedlots of Japanese larch (four), European larch (seven), and tamarack (one). These were planted out at Portage du Fort, western Quebec, in eight replications of 10 tree (2 x 5) plots with the objective of demonstrating heterosis of the hybrids and investigating variability among the various European larch races when used as one of the parents.

Heights, diameters, and the incidence of crookedness, forking, and damage due to porcupine and sapsucker were recorded in 1987 at age of 15 (Table 7). Eight of the 10 tallest seedlots were hybrid, with an "Alpine" x Japanese hybrid exceeding 10 m in average height at age 15. Eight out of the 10 seedlots with the largest diameter were also hybrids. A secondary European source ranked third both for height and diameter, while the "Polish" provenance, Blizyn, was fifth tallest and had the seventh largest diameter. The hybrids that had "Alpine" European parents and the single seedlot with a "Polish" European parent were in both cases significantly taller than those with "Sudeten" parents ($P<0.01$). "Alpine" hybrids also had a significantly larger diameter than the "Sudeten" hybrids.

The frequency of crooked stems ranged from zero for a secondary European source to 60% for the local tamarack. Both the "Alpine" and "Sudeten" hybrids averaged around 15% crooked stems, and the single "Polish" hybrid had 5% crooked stems. Forked stems were infrequent, with no seedlot exceeding 5%. Porcupine damage

Table 7. Results of experiment 378-A, age 15 (1987).

Seedlot	Origin	Height	Diameter	% crooked	% forked
7310	"Alpine" x Japanese	10.3 a	13.8 a	10	a
7302	"Polish" x Japanese	9.9 ab	12.7 abc	5	3
7347	European via Bergen	9.8 abc	13.1 a	25	3
7306	"Alpine" x Japanese	9.6 abc	13.1 ab	24	0
7474	European, Blizyn	9.5 abc	12.6 abc	30	3
7305	"Sudeten" x Japanese	9.5 abc	11.6 abc	24	5
7301	"Alpine" x Japanese	9.4 abcd	12.9 abc	8	3
7473	"Alpine" via Denmark	9.4 abcd	11.4 abc	30	0
7480	Hybrid via Sweden	9.3 abcd	12.0 abc	10	3
6688	Hybrid via Denmark	9.1 abcd	13.9 a	3	0
6687	European via Denmark	8.9 abcd	11.0 abc	0	3
7482	"Alpine", eastern Austria	8.9 abcd	10.9 abc	21	0
7293	"Sudeten" x Japanese	8.6 abcd	11.0 abc	13	3
7477	Japanese via Denmark	8.5 abcd	10.9 abc	25	0
7277	Japanese, Kuniyama	8.5 abcd	11.9 abc	33	0
7297	"Sudeten" x Japanese	8.3 abcd	11.7 abc	15	0
7476	Japanese via Denmark	8.3 abcd	10.6 abc	18	0
7304	Japanese via DDR	8.2 bcd	10.6 abc	44	3
7475	European via Quebec	8.1 cd	9.9 bc	5	2
5388	Tamarack, PNFI	7.6 d	9.2 c	60	3

Note: Seedlots having the same letter are not significantly different at the 5% significance level, as calculated from Bonferroni's t-test.

was also slight, occurring on only 5% of the stems, and sapsucker damage was negligible. In experiment 209-A, *L. eurolepis* obtained via Faarefolder, Denmark was heavily defoliated by the larch sawfly.

b) Other hybrids

Experiment 381-B-2 contains 32 (mostly) control-pollinated seedlots among selected trees, planted as 10-tree row plots in five replications at Lake Doré, near PNFI. In 1981, at age 9 from seed and five years after field planting, heights were recorded (Table 8). Only five of the seedlots are hybrids; two *L. gmelini* x *L. decidua*, two *L. decidua* x *L. sibirica*, and one *L. eurolepis* ("Sudeten" x Japanese). Many of the remaining seedlots are interracial hybrids of European larch.

Apart from the *L. eurolepis* seedlot, which ranked fourth with an average height of 7.0 m at age 9, the hybrids performed poorly. The better seedlot of both *L. gmelini* x *L. decidua* and *L. decidua* x *L. sibirica* hybrids averaged 6.0 m at age 9 on what is a very rich, calcareous site.

Discussion of larch hybrid experiments

From this limited amount of material, it appears that only *L. eurolepis* of the hybrids tested holds any potential for good productivity under conditions in eastern Ontario and western Québec. The results from experiment 378-A may seem somewhat anomalous in that the "Alpine" hybrids performed significantly better than the "Sudeten" hybrids. The "Alpine" parents of these hybrids originated from secondary sources, however, and had thus undergone several generations of selection. As with the pure species, seed obtained from secondary sources is likely to be of higher quality than that from unimproved material, at least in terms of stem form.

Based on tests in Japan, Takahashi and Hamaya (1972) identified *L. gmelini* x *L. eurolepis* as having superior growth rates and stem form, improved frost hardiness, and high resistance to needle cast and canker compared with the pure species or other hybrids. No *L. gmelini* x *L. leptolepis* hybrids have been tested at PNFI, but experience with pure *L. gmelini* and hybrids between *L. gmelini* and both *L. sibirica* and *L. decidua* suggest that growth rates would be unsatisfactory.

In a species trial in Wisconsin, Riemenschneider and Nienstaedt (1983) reported

Table 8. Expt. 381-B-2: Comparison of larch species and hybrids

Seedlot	Description	Age 10 height (m)	No. of trees
7409	ST2514 x ST2450 *L. gmelini* x *L. decidua* (Pol)	5.05	18
7418	ST2521 x ST2524 *L. decidua* (Alpine)	5.52	21
7408	*L. gmelini* open-pollinated	5.61	40
7426	ST2524 x ST2533 *L. decidua* (Sud) x *L. sukaczewii*	5.62	25
7417	ST2521 x ST2516 *L. decidua* (Alpine)	5.68	7
7411	*L. decidua* open-pollinated (Alpine)	5.76	42
7415	*L. decidua* open-pollinated (Alpine)	5.88	383
7406	ST2506 x ST2536 *L. decidua* (Alpine x Sudeten)	5.90	1
7419	ST2521 x ST2450 *L. decidua* (Alpine x Polish)	5.90	3
7424	ST2522 x ST2532 *L. decidua* (Alpine)	5.92	23
7429	ST2526 x ST2533 *L. decidua* (Sud) x *L. sukaczewii*	5.96	52
7416	ST2521 x ST2536 *L. decidua* (Alpine x Sudeten)	6.03	19
7410	ST2514 x ST2526 *L. gmelini* x *L. decidua* (Sudeten)	6.04	14
7428	ST2526 x ST2532 *L. decidua* (Sudeten x Alpine)	6.04	55
7413	ST2517 x ST2524 *L. decidua* (Alpine)	6.06	10
7420	ST2521 x ST2512 *L. decidua* (Alpine x Polish)	6.06	45
7398	ST2504 x ST2503 *L. decidua* (Alpine)	6.09	8
7391	*L. decidua* open-pollinated (Alpine)	6.10	18
7423	ST2522 x ST2524 *L. decidua* (Alpine x Sudeten)	6.12	9
7425	*L. decidua* open-pollinated (Sudeten)	6.12	25
7421	ST2521 x ST2526 *L. decidua* (Alpine x Sudeten)	6.15	4
7427	*L. decidua* open-pollinated (Sudeten)	6.17	261
7414	ST2517 x ST2532 *L. decidua* (Alpine)	6.24	4
7412	ST2517 x ST2516 *L. decidua* (Alpine)	6.35	5
7431	ST2526 x ST2450 *L. decidua* (Sudeten x Polish)	6.78	2
7397	*L. decidua* open-pollinated (Alpine)	6.85	2
7405	St2506 x ST2500 *L. decidua* (Alpine)	6.95	1
7430	ST2526 x ST2538 *L. eurolepis* (Sudeten x Japanese)	7.00	4
7422	ST2522 x ST2516 *L. decidua* (Alpine)	7.08	3
7399	ST2504 x ST2530 *L. decidua* (Alpine x Sudeten)	7.08	2
7432	ST2526 x ST2524 *L. decidua* (Sudeten x Alpine)	7.09	19

that a Siberian larch seed source ranked third for 8-year height, and second in 5- to 8-year height increment, behind only *L. eurolepis*. However, they suggested that the *L. sibirica* seedlot actually contained a substantial number of *L. sibirica* x *decidua* hybrids, hence the reason for the outstanding performance of the seedlot. Certainly, in the Soviet Union, the *L. sibirica* x *decidua* hybrid is considered the most productive for boreal regions. (Ms. E.S. Liubich, pers. comm.). This hybrid, therefore, deserves more investigation for use in the boreal regions of Ontario and Quebec.

4) Tamarack

Much of the early work on larch at PNFI concentrated on exotics and hybrids. Samples of tamarack were only rarely included in these early tests, and even then it was as a form of "control". It is only recently that the potential of tamarack as a commercial species has been recognized, especially for short-rotation pulpwood plantations, due to its superior early growth rates compared to species such as black spruce (Fayle 1979). Consequently, most experiments dealing with tamarack at PNFI are quite young. For example, seed collection for a series of range-wide provenance tests in tamarack was only initiated in the 1970s and, due to problems with periodicity and seed yield, field tests have only been established in the period 1985-87.

a) Provenance sampling

A series of three field tests of the range-wide provenance samples were planted at PNFI and at Espanola and Hearst in Ontario during 1986-87 (Expts. 424-6,8,9). No data are yet available from these tests.

b) Progeny tests

A series of replicated experiments were established in 1971 to compare different methods of plus tree selection (series 376-A). Open-pollinated seed was collected from between two and 14 individuals in three natural populations in eastern Ontario, and two PNFI plantations, for a total of 36 families. The three methods of plus tree selec-

tion were, in reality, the same method applied to different categories of material: plantation-grown, young natural trees, and old natural trees. For this reason, each "method" was applied to a population as a whole and, consequently, any genetic differences among populations are potentially partially confounded with selection method. Progeny of the selected trees were outplanted on three markedly different sites at PNFI – a wet site, a dry site, and on infertile sand.

In 1987, at age 16 from seed, the three field experiments were assessed for height, diameter, and frequency of crookedness, forking (Fig. 4), porcupine damage (Fig. 5), suppressed trees, dead/missing trees (Fig. 6), and twisted trees, the last character being a gross distortion of growth habit, resulting in total loss of commercial value. The data were analyzed to provide estimates of family repeatability. However, the variance components for families was zero in many cases, especially for height growth, yielding zero estimates of repeatability (Table 9).

Clearly, the lack of variation among families from Adelard and between the two from Bancroft contributed greatly to the absence of overall variation. However, even though PNFI families, which represented selections from plantation trees, exhibited variation at each site individually, a pooling of data over all sites resulted in a zero family variance component, reflecting the very great differences among sites and also among replications within sites, especially at highly variable Site 2. Smith (1985), analyzing 13-year data, found the same lack of variation among families for height growth.

In 1988-89 a series of open-pollinated family tests of material from a subset of the range-wide provenance samples were established on the same three sites as the provenance tests (PNFI, Espanola, Hearst → Expts. 424-10,11,12). Unfortunately, due to extreme drought conditions, the Espanola experiment suffered 50% mortality in the first year and had to be abandoned.

Discussion of tamarack experiments

The absence of variation in the 376-A series would seem to indicate that genetic improvement for height growth in tamarack is possible only through provenance selection and, possibly, intraspecific hybridization. But it should be remembered that the families in these experiments were fairly intensively selected, and it can be expected that variation among them would be lower than for a random sample.

Nevertheless, family repeatability for height growth in tamarack would appear to be lower than for many species, although Park and Fowler (1982, 1987) report substantial levels of variation among both open-pollinated and control-pollinated families. Park and Fowler (1987) estimated narrow sense heritabilities for 5-year height ranging from 0.01 to 0.14 over three sites and clone mean heritabilities of 0.44 to 0.80. They concluded that there were high levels of additive genetic variation for height growth but that, for survival, non-addition variation was of greater importance.

Similarly, analyses of the frequency of negative characters indicated very large environmental differences, but few differences among populations or families (Table 10). Mortality was very much greater on the two drier sites than on the moist site, but porcupine damage was greater on the moist site due to the proximity of suitable cover. The frequency of suppressed trees was higher where mortality was lower. It is perhaps surprising that crookedness, forking, and twisting

Table 9. **Expt. 376-A: Maximum likelihood estimates of family variance components for height growth. "+" indicates positive estimates, (0) indicates a trivially positive estimate.**

Site/Pop Df	Adelarde 6	Bancroft 1	PNFI 5	Sand Lake 6	Young Creek 7	All pops.
1	0	0	+	+	0	+
2	0	0	+	0	0	0
3	0	(0)	+	0	+	+
All sites	0	0	0	0	0	0

Fig. 4. Forked and crooked tamarack.

Fig. 5. Porcupine damage in tamarack.

Fig. 6. "Twisted" tamarack - severe stem deformation.

should show so much variation among sites, but the influence of the environment is readily apparent in the plantations, especially for the last of these characters, with groups of trees in an area of 40-80 m^2 all being twisted, and those trees around the border of such groups being very crooked. This phenomenon is particularly apparent on the dry, sandy Site 2, and is clearly unrelated to genetic origin of the trees because it spreads across the row plots. Simak and Jeansson (1987) reported excessive damage to tamarack from a variety of agents such as moose, insects, and frost in northern Sweden, but the incidence of damage from these sources differed greatly with site. Despite a large moose population in the vicinity of PNFI, damage to experimental plots of larch has been minimal.

The original objective of these experiments was to compare methods of plus tree selection. Comparing plantation selections against natural population selections indicated that the former produced an improvement in height growth significant at the 5% level. This improvement was due largely to the superior performance of plantation-selected families on the drier sites, 2 and 3. The plantation in which the selections were made is on a wet site, but it is not clear from the records whether the plantation trees themselves originated from seed collected from trees growing on a dry site. Results from this series of experiments are discussed in greater detail in Boyle et al. (in prep).

The plantation-selected families showed no superiority for any of the qualitative characters. It would seem, therefore, that high heritability characters such as stem form can be selected equally well in natural or artificial populations, but low heritability characters, such as height, are more efficiently selected in artificial populations, as would be expected. Smith (1985), by comparing rank correlation coefficients for height at ages 4, 5, 6, 9, and 13 for this material, concluded that the optimum selection age in terms of genetic gain per year is 11. Without the benefit of provenance test results, it can be suggested that a suitable improvement strategy for tamarack would involve selection on the basis of stem form in local natural populations if local-origin plantations are not available, followed by the establishment of family tests and selection for height growth in these at about age 11. Studies on genetic organization of natural populations have indicated that at least 60 m should be left between selections because of relatedness (Park and Fowler 1982).

In fact, the limited quantity of information available for provenance variation in tamarack suggests that local provenances, or those from slightly more southerly locations, are usually among the best (Jeffers 1975, Riemenschneider and Jeffers 1980, Cech et al. 1977). Simpson (1983) proposed an improvement strategy for tamarack based on selection in natural populations followed by establishment of clonal seed and breeding orchards. Subsequent selections would be made at age 10 in field tests containing families from pair-matings in the breeding orchards, whilst roguing in the seed orchard would be based on 10-year results from polycross families of breeding orchard clones.

Fowler (1986, 1987) suggested an alternative strategy designed to exploit the non-additive component of genetic variation. Surplus seed from polycrosses among clones of plus trees would be wed in the first generation for vegetative propagation. The remaining seed would be used to establish progeny tests, in which 10-year height would be used to identify the best 40 GCA parental clones. Disconnected half diallels among

Table 10. **Expt. 376-A: Significance levels for variance components for qualitative and survival characters. NS indicates not significant at the 5% level; * indicates significance at the 5% level, and ** at the 1% level.**

Character/Var. comp.	Site	Population	Family (Pop.)	Site x Pop. Interaction
Dead	**	NS	NS	NS
Crooked	**	NS	**	NS
Forked	**	NS	NS	NS
Porcupine damaged	**	NS	NS	NS
Suppressed	**	NS	*	NS
Twisted	**	NS	NS	*

groups of these 40 clones would then generate material for further vegetative propagation and selection.

5) Other species

Most work at PNFI with other larch species and hybrids has suffered from a lack of knowledge of the exact origin of the material. Only one replicated experiment has been devoted to minor larch species; experiment 377-A-1 is a family test of open-pollinated families from *L. sibirica* maternal parents growing in a clonal archive in Finland. However, the origin of the parents is unknown and the presence of other species in the archive allows the possibility of hybridization in the progeny.

Results from the small samples of seedlots in unreplicated experiments suggest that *L. gmelini* and hybrids with other species have no commercial potential in eastern Ontario and western Québec. Similarly, in a plantation of *L. occidentalis*, survival in the two seedlots averaged less than 10% at age 10 and the surviving trees were growing very slowly (Fig. 7).

Performance of *L. sukaszewii* and *L. sibirica* has been less consistent, partly as a result of very limited sampling of huge natural ranges.. It is apparent that northern seed sources are of little value, but in trial plantations near Kapuskasing, Ont. *L. sibirica* sources grew faster than *L. decidua*. Similarly, in one unreplicated experiment at PNFI, a *L. sukaczewii* seedlot via Manitoba grew faster than any other species, apart from one seedlot of *L. decidua* from the Sudeten Mountains (Fig. 8). Southern sources of *L. sibirica* from approximately 50°-52° N may have some value in the more northerly forest regions of eastern Canada.

SPECIES COMPARISON

With the exception of European larch, none of the larch species included in PNFI experiments demonstrate very high levels of variability, at least for the population samples at hand. For example, the tamarack in experiments 376-A-1-1 to 3 demonstrated only small differences among populations and no variability among families within populations. Similarly, the Japanese larch provenances in experiment 375-A were not significantly different for either height or diameter at age 15. The Siberian larch of 377-A-1 was also almost uniformly poor. Even for European larch, the only major distinction in performance was between "Alpine" sources and others, with variability among secondary sources apparently being merely a function of intensity of the selection to which they had been exposed. As previously noted, however, other studies have indicated significant varition within larch species (e.g. for Japanese larch, Park and Fowler (1987) and for tamarack, Simak and Jeansson (1987)).

Fig. 7. Western larch (Expt. 209 H) - only 3 trees survive.

Population x environment and family x environment interactions were non-significant for tamarack in the 376 series but for Japanese larch such interactions were often highly significant. In the 209 series, product-moment correlations among sites were not always significant, but the diversity of the sites and the differential survival and thinning treatment among sites, together with the small sample size, complicated matters.

Fig. 8. Siberian larch via Denmark (possible hybrid). Most productive seedlot in Expt. 35.

When low within-species variability and generally non-significant genotype x environment interactions occur, species comparisons are simple. In many cases, seedlots of several species and hybrids were included in the same experiment, although samples sizes were often correspondingly small. Another valid comparison, however, can be made in the case where species are planted in adjacent experiments. Such is the case in one plantation area at PNFI, where four species: tamarack (376-A-1-1), European larch (381-B-1), Japanese larch (375-A), and Siberian larch (377-A-1), all of the same age, were planted adjacent to each other, with the other three species occupying one side each of the Siberian larch experiment. All these experiments were measured in 1987 at age 15 (Table 11). Heights, diameters, survival, stem form, and damage ratings were assessed in all the experiments except 377-A-1, the Siberian larch being generally too small to enable anything other than height and survival to be recorded. Comparative growth curves for European larch (primary and secondary sources), Japanese larch, *L. eurolepis*, tamarack, and other species are shown in Figure 9a-f.

Clearly, Siberian larch is totally unsuitable for conditions in eastern Ontario and western Quebec. Japanese larch is also of doubtful value, largely because it tends to suffer from repeated winter damage in the continental climate of PNFI. Further south, where the moderating influence of the Great Lakes maintain slightly higher winter temperatures, and also in the Maritime provinces, tree improvement programs for Japanese larch may be feasible (Hood et al. 1988). Rauter (1980) reported that *L. eurolepis* grew fastest over three sites in southern Ontario, followed by Japanese larch, European larch, and tamarack. Survival of Japanese larch remains a problem, however, with only 55% survival in 375-A, less than 10% in 209-F, and highly variable rates even in the 428 series located in southeastern Ontario and southern Quebec. In a number of experiments containing both Japanese and European larch, diameter growth rate of Japanese tends to equal or surpass European, although such was not the case in the 381-B-1/375-A comparison above.

The tamarack in the 376 series originated from selections in natural stands and plantations. Growth rate and stem form are, therefore, superior to other tamarack seedlots scattered around several experiments. Although height growth can exceed European larch, the typically smaller diameters of tamarack result in lower volumes per hectare. In the more equable climate of the Maritime provinces Park and Fowler (1983) found that height growth of tamarack was superior to that of European larch, but exceeded Japanese larch only up to age 4. As with all the larches, stem form of unimproved material is generally poor. Rates of porcupine damage in Table SC1 should not be taken as an indication of preferential feeding on the indigenous species. An examination of the spatial distribution of damage indicated a very strong relationship with proximity to the natural forest, where the porcupines presumably reside. There was a marked decrease in frequency of damage with increasing distance from the natural forest. The tamarack plantation lies between the other experiments and the natural forest, which results in lower levels of damage on the Japanese and European larches. Park and Fowler (1983) report preferential feeding of porcupines on European larch, with Japanese larch least affected. The possibility of spatial effects in their data is not clear.

Table 11. **Age 15 assessments of experiments 381B1, 376A11, 375A, and 377A1 (height in m; diameter in cm; others in %).**

Expt.	Species/material	Height	Diameter	Crooked	Forked	Porc.	Survival
381B1	European, via Den.	7.8	8.9	1	5	3	?
375A	Japanese, provenances	6.8	7.7	11	1	2	55
377A1	Siberian, via Fin.	4.5	-	-	-	-	40
376A11	Tamarack, local	8.7	8.4	8	11	8	?

In any experiment containing *L. eurolepis*, for example the 209 series and 378-A, both height growth and diameter growth of the hybrid almost invariably exceed those of any pure species. Stem form also tends to be better, though this is certainly partially due to the use of selected parents. In addition, hybrid larch combines the canker resistance of Japanese larch with adequate winter hardiness to survive winter conditions at PNFI. Due to the inferiority of F2 hybrids (LeCam 1982) the major problem with the use of *L. eurolepis* in artificial regeneration programs is the need to reproduce F1 hybrids. Thus, although hybrid larch would seem to be the most suitable larch species in this region of Canada, any utilization strategy must consider the selection and breeding of both parents. The ease with which larch can be vegetatively propagated through rooting of juvenile cuttings provides a mechanism by which limited quantities of seed can extensively used. In southern Ontario, Quebec, and the Maritimes the performance of pure Japanese larch may be adequate to justify an improvement program for the pure species alone, whilst in the boreal forest, where the hybrid and even European larch may not be sufficiently hardy, tamarack is likely to be the species of choice. In northern Ontario, based on the growth of a few trees in the unreplicated experiment 66 at Kapuskasing, Siberian larch from southern Siberian sources may be superior to European larch (see Appendix II).

What is clear from all these studies is that site differences account for many of the anomalies in species comparisons and that site selection is, therefore, crucial for all larch species.

Genys and Harman (1976) found distinctly different growth rates and susceptibility to sawfly among different species and hybrids. Hybrids of the F2 generation of Japanese and European larch grew most rapidly but were highly susceptible to sawfly, as was a hybrid in our tests; Japanese larch was most susceptible, Daliurian and Siberian larches were about equal, whereas western larch, *Larix occidentalis*, was least susceptible.

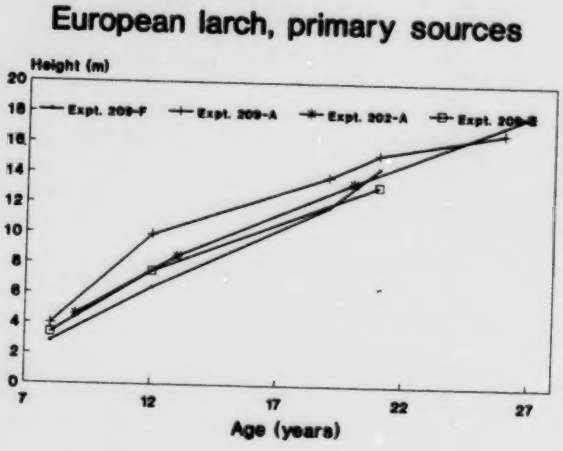
Nicks (1989) has reported on pulping trials carried out by E.B. Eddy Forest Products Ltd. on tamarack and tamarack/jack pine (*Pinus banksiana* Lamb.) mixtures. He concluded that substitutions of up to 10% tamarack were practical and these results justified an improvement program for tamarack.

In 1980, European larch thinnings from Exp. 209-A were sent for pulping trials by Domtar Packaging of East Angus, Quebec. As shown in Table 19, European larch was intermediate between tamarack and spruce-fir chips in several wood quality and pulping characters such as relative density, beating time required to reach a specified freeness, and resulting paper density. The two larches were similar but inferior to the spruce-fir in terms of brightness; European larch was inferior for several strength parameters.

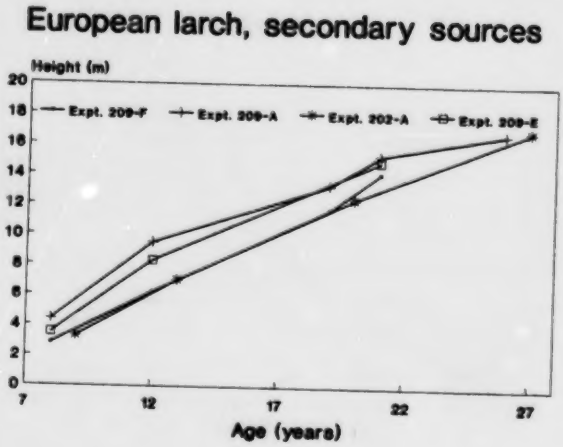
CONCLUSIONS

Since 1926, and especially since the 1950s, 126 experimental plantations of the genus *Larix* have been established by PNFI. Although many of these plantations, particularly the early ones, were often simple observational trials, being unreplicated and containing a limited sample of material, the age of these plantations, combined with information from larger replicated tests, has provided a considerable amount of valuable information on the potential of larch species in eastern Canada.

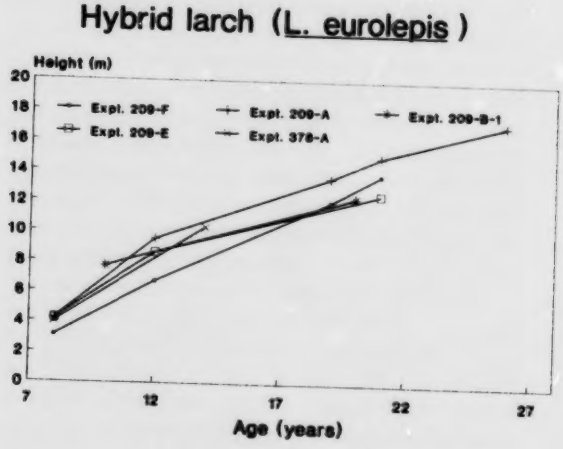
Fig. 9a-f. Comparitive growth data for species comparison.



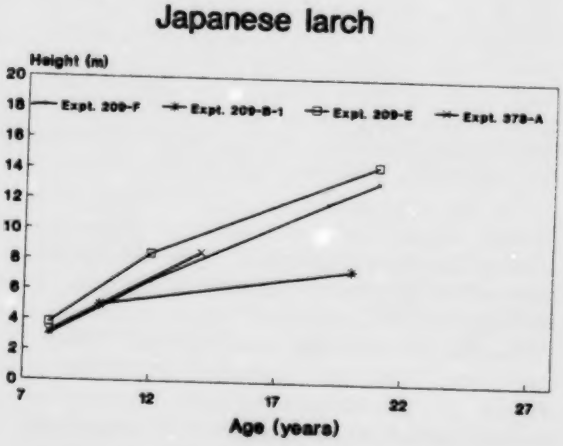
a. European larch, primary sources.



b. European larch, secondary sources.

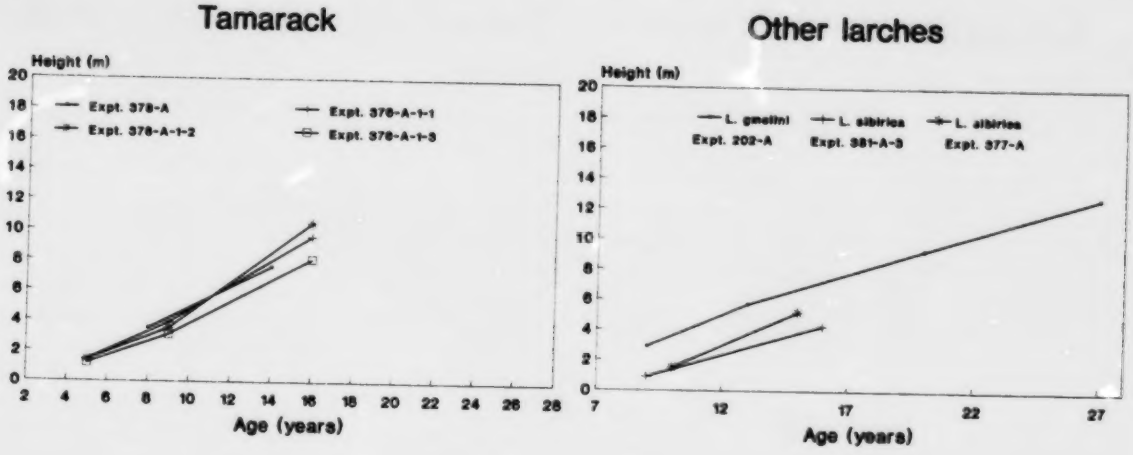


c. Hybrid larch (*L. eurolepis*)



d. Japanese larch

Fig. 9. Continued



e. Tamarack

Many recommendations can be made with confidence. For example, it is clear that pure Japanese larch is too susceptible to winter damage to be of any value in areas away from the influences of the Great Lakes - St. Lawrence Valley, except in the Maritimes. Conversely, pure Siberian larch may perform adequately only in the boreal regions of northern Ontario and Quebec. Both growth rate and stem form can be easily improved by mass selection. Thus, the selection of material for establishing a breeding population, whether it be for the propagation of a pure species or a hybrid, should concentrate either on secondary sources that have undergone some selection or high yielding primary sources. In the case of European larch, the latter category includes "Sudeten" provenances, as well as many "Polish" and some "Tatra" provenances. Further work is required to provide information on a range of topics, including the potential of additional hybrids, such as European x Siberian, on a range of sites; the accurate estimation of heritabilities and genetic correlations of commercially important traits in all species; the genetics of F2 hybrids; and pathological problems.

f. Other species

For tamarack, as for the exotics, selection in the relatively controlled conditions of a plantation will yield greater genetic gain. In addition to improvement of stem form, a tree improvement program for tamarack should consider the interaction of silviculture with genetic improvement to optimize volume production. Although local tamarack can exceed exotic larches in terms of height growth, the slightly slower diameter growth of tamarack results in lower individual tree volumes. As diameter growth rates are typically under such weak genetic control, genetic improvement of tamarack will not allow it to compete with European larch in terms of productivity except under extreme continental climatic conditions to which European larch is not adapted. Diameter growth is more easily controlled by silvicultural treatment, and an investigation of the interaction between spacing and productivity in tamarack is underway at PNFI (for 15-year results see Stiell 1986).

Acknowledgments

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Table 12. Wood quality, pulp, and paper comparisons

Trait	European larch	Tamarack	Spruce-fir
Relative density	0.38	0.42	0.35
Beating time to reach 550 Can. St. freeness (min.)	18	22.5	15
Paper density	11.25	11.72	11.00
Brightness (%)	17.0	17.0	24.5
Tear ($mN.m^2/g$)	21	23	27
Burst factor	120	120	144
Strength	35	39	43
Stretch	3.0	3.0	2.9

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APPENDIX I

Larch seedlots represented in PNFI experiments

1. L. DECIDUA

Seedlot #	Origin	Lat.	Long.	Experiment numbers																
				ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
S.1337	Czechoslovakia					x															
1412	Hoersholm, Denmark	55.48	12.18			x															
1413	Hoersholm, Denmark	55.48	12.18			x															
1605	Hoersholm, Denmark	55.48	12.18			x															
1606	Hoersholm, Denmark	55.48	12.18			x															
1607	Hoersholm, Denmark	55.48	12.18			x															
1608	Hoersholm, Denmark	55.48	12.18			x															
1616	Farum, Denmark	55.48	12.18			x	x	x	x												
1617	Farum, Denmark	55.48	12.18			x	x	x	x												
1618	Farum, Denmark	55.48	12.18			x	x	x	x												
1619	Noedebo, Denmark	56.00	12.10			x															
1620	Tegelstrup Hegn, Denmark	56.00	12.10			x															
1621	Farum, Denmark	56.00	12.10			x															
1622	Gurre, Denmark	56.00	12.10			x															
1623	Lellinge, Denmark	55.28	12.08			x															
1886	Rosalia, Austria	47.35	16.15								x	x			x						
1887	Paternion, Austria	46.40	13.35								x	x			x						
1894	Kroscienko, Poland	49.29	20.25							x	x	x	x								
2145	Krakow, Poland	50.00	20.00								x			x							
2316	Wroclaw, Poland	50.20	16.50										x								
2498	Blizyn, Poland	50.05	20.40										x								
2499	Kroszienko, Poland	49.26	20.25										x								
2500	Krojec, Poland	51.15	20.45										x								
2501	Scarzysko, Poland	51.15	20.45										x								
2502	Farum, Denmark	55.48	12.18										x	x							
2525	Jaegersborg Hegn, Denm.	55.45	12.30											x							
2526	Nejede Vester, Denmark													x							
2527	Schlitz, Germany	50.40	09.30											x							
2655	Farum, Denmark	55.48	12.18												x						
2656	Farum, Denmark	55.48	12.18												x						
2845	Sabinov, Czechoslovakia	49.04	21.00												x						
2846	Krnov Radin, Cze.	50.05	17.40												x						
2847	Parsovice, Cze.	49.30	17.42												x						
2848	Trencin, Czechoslovakia	48.59	18.01												x						
2849	Tatranska, Cze.	49.08	20.12												x						
2850	Cierny Vah, Cze.	49 00	19.56												x						
2851	Cervena Skala, Cze.	48.51	20.10												x						
3302	Galicia, USSR	48.55	25.42												x						
6687	Rundforbi, Denmark	55.50	12.30																		
7220	P.N.F.I.	45.58	77.26																x	x	
7244	P.N.F.I.	45.58	77.26																	x	
7246	P.N.F.I. Ont.	45.58	77.26																	x	
7248	P.N.F.I. Ont.	45.58	77.26																	x	
7262	Punkaharju, Finland	61.43	29.25																	x	

1. L. DECIDUA (contd.)

Seedlot #	Origin	Lat.	Long.	Experiment numbers																
				ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
7263	Punkaharju, Finland	61.43	29.25																	x	
7284	Morayshire, Scotland	57.39	03.20																	x	
7285	Morayrhire, Scotland	57.39	03.20																	x	
7286	Morayshire, Scotland	57.39	03.20																	x	
7287	Morayshire, Scotland	57.39	03.20																	x	
7288	Morayshire, Scotland	57.39	03.20																	x	
7289	Morayshire, Scotland	57.39	03.20																	x	
7347	Bergen, Germany	47.48	12.36																x		
7391	P.N.F.I. Ont.	45.58	77.26																	x	
7393	P.N.F.I. Ont.	45.58	77.26																	x	
7397	P.N.F.I. Ont.	45.58	77.26																	x	
7401	P.N.F.I. Ont.	45.58	77.26																	x	
7411	P.N.F.I. Ont.	45.58	77.26																	x	
7415	P.N.F.I. Ont.	45.58	77.26																	x	
7425	P.N.F.I. Ont.	45.58	77.26																	x	
7427	P.N.F.I. Ont.	45.58	77.26																	x	
7473	Ganlose Ege, Denmark																		x		
7474	Blizyn, Poland	51.00	20.44																x	x	
7475	Berthierville, Que.	46.05	73.11																x		
7482	Eastern Alps, Austria																		x		
7786	Jaegersborg, Denmark	55.45	12.30																x		
9462	Jaegersborg, Denmark	55.45	12.30												x						
20169	P.N.F.I. Ont.	45.58	77.26			x															
20170	P.N.F.I. Ont.	45.58	77.26			x															
20290	Suchelniow, Poland	51.03	20.38			x															
20291	Barbo Slaskie, Poland	50.28	16.41			x															
20292	Stary Sacz, Poland	49.27	20.24			x															

Total 71 seedlots

2. L. LEPTOLEPIS

Seedlot #	Origin	Lat.	Long.	Experiment numbers																
				ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
	Dunkeld, Scotland	56.34	3.36		x																
383	P.N.F.I. Ont.	45.58	77.26	x																	
1609	Hoersholm, Denmark	54.48	12.18			x															
1610	Hoersholm, Denmark	54.48	12.18			x															
1611	Hoersholm, Denmark	54.48	12.18			x															
2522	Hoersholm, Denmark	54.48	12.18											x							
2523	Buderupholm, Denmark	56.50	11.50											x							
3326	Aniva, Sakhalin, USSR	46.20	142.30												x						
3327	Iuzhno Sakhalin, USSR	47.00	142.45												x						
5374	Karanatsu, Japan																				x
6689	Honshu, Japan															x			x		x
6690	Gdansk, Poland	54.20	18.40																		x
6843	Kumashiro Yama, Japan	36.31	138.27													x					
6844	Mizunoto, Japan	36.24	138.28													x					

2. L. LEPTOLEPIS (contd.)

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
6845	Yashuhara, Japan	36.38	139.32													x					
7252	Ottawa, Ont.	45.25	75.43																	x	
7253	Ottawa, Ont.	45.25	75.43																	x	
7256	Ottawa, Ont.	45.25	75.43																	x	
7262	Honshu, Japan																		x	x	
7264	Tuoaarin-Kyla, Finland																			x	
7267	Solbole, Finland																			x	x
7277	Hokkaido, Japan																		x	x	
7278	Dunkeld, Scotland																			x	x
7279	Dalbeattie, Scotland	54.55	03.50																	x	x
7280	Fairburn, Scotland.																			x	x
7281	Cardcross, Scotland	55.58	04.30																	x	x
7282	Glendye, Scotland.																			x	
7283	Farum, Denmark	55.48	12.18																	x	x
7290	North Strome, Scotland															x					x
7291	Dalbeattie, Scotland	54.55	03.50													x					x
7292	Yatsugata, Japan	35.58	138.22																		x
7304	East Germany																		x		x
7307	Sekigawa, Japan	35.30	136.54													x					
7308	Honshu, Japan																				x
7309	Kamikawa, Japan	43.45	142.44													x					
7476	Sostrup, Denmark	55.30	11.50																x		x
7477	Sostrup, Denmark	55.30	11.50																x		x
7478	Feldborg, Denmark	56.20	08.30																	x	x
7479	Sostrup, Denmark	55.30	11.50																	x	x
7481	Hondo, Japan	32.28	130.12																		x
7483	Dejbjerg, Denmark	56.00	8.26																		x
7490	Harrington, Que.	45.51	74.38																		x
7793	Flensborg, Denmark	55.00	09.30																		x
7794	Flensborg, Denmark	55.00	09.30																		x
7795	Lindersvold, Denmark	56.50	11.50																		x
7796	Nagano Ven, Japan	36.37	138.10																		x
8902-8950	Tokachi Hokkaido, Japan incl.	43.00	141.30																		x
8951	Central Honshu, Japan																				x
8952	Hokkaido, Japan																				x
8953	Nagano, Japan	36.39	138.10																		x
8954	Kumashiroyama G'na, Jap.																				x
8955	Mizunoto Gunna, Japan																				x
8956	Flensburg, Denmark	55.00	09.30																		x
8957	Gavno Lindersvold, Denm.	56.50	11.50																		x
8958	Flensburg, Denmark	55.00	09.30																		x
8959	Yamanashi Pref., Japan																				x
8960	Nagano Pref., Japan	35.20	138.43																		x
9861	" " "	36.23	138.22																		x
9862	" " "	35.55	138.18																		x
9863	" " "	35 52	137.32																		x
9864	" " "																				x

Total 103 seedlots

3. L. x EUROLEPIS

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
-	Dunkeld, Scotland	56.34	3.36		x																
76	F2 P.N.F.I. Ont.	45.58	77.26	x																	
88	F2 P.N.F.I. Ont.	45.58	77.26	x																	
326	Boston, U.S.A.	42.20	71.05	x																	
354	F2 P.N.F.I. Ont.	45.58	77.26	x																	
384	F2 P.N.F.I. Ont.	45.58	77.26	x																	
1612	Horsholm, Denmark	55.48	12.18		x																
2524	Faarefolden, Denmark	56.28	8.17											x							
6688	Faarefolden, Denmark	56.28	8.17																x		
7278	Dunkeld, Scotland	56.34	3.36																x		
7279	Dunkeld, Scotland	56.34	3.36																x		
7280	Dunkeld, Scotland	56.34	3.36																x		
7281	Dunkeld, Scotland	56.34	3.36																x		
7282	Dunkeld, Scotland	56.34	3.36																x		
7283	Farum, Denmark	55.48	12.18																x		
7284	Dunkeld, Scotland	56.34	3.36																x		
7285	Dunkeld, Scotland	56.34	3.36																x		
7287	Dunkeld, Scotland	56.34	3.36																x		
7293	Basnas, Denmark																		x		
7294	Basnas, Denmark																		x		
7295	Basnas, Denmark																		x		
7298	Basnas, Denmark																		x		
7299	Basnas, Denmark																		x		
7300	Basnas, Denmark																		x		
7301	Faarefolden, Denmark	56.28	8.17																x		
7302	Christianmunde, Denmark																		x		
7305	East Germany																		x		
7306	East Germany																		x		
7480	Visingoe, Sweden	58.02	14.20																x		
9981	Germany														x						
9982	Germany														x						

Total 33 seedlots

4. L. SIBIRICA

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
10	Ural Mts., USSR			x																	
385	Dropmore, Man.	51.01	101.26	x																	
386	Dropmore, Man.	51.01	101.26	x																	
434	Punkaharju, Finland	61.43	29.25						x												
1613	Horsholm, Denmark	55.48	12.18			x															
1711	Raivola, Finland								x		x										
1895	Dropmore, Man.	51.01	101.26			x															
3111	Krasnoiarsk, USSR	56.00	92.00												x						

4. L. SIBIRICA (contd.)

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
3301	Sokol, USSR	59.20	40.20												x						
3304	Kalingrad, USSR	54.40	21.00												x						
3306	Kudymkar, USSR	59.02	54.42												x						
3307	Okhansk, USSR	57.18	55.22												x						
3308	Uchaly,Baskiria, USSR	54.21	59.28												x						
3311	Novay Lyalya, USSR	59.04	60.39												x						
3315	Shebalina, USSR	51.33	85.40												x						
3316	Ust Kan, USSR	50.57	84.47												x						
3317	Charyshkoi, USSR	51.23	83.32												x						
3318	Kazachinskoe, USSR	57.37	93.20												x						
3322	Angarsk, USSR	52.33	103.55												x						
3323	Chagonar, USSR	51.45	92.50												x						
3324	Chagonar, USSR	50.45	92.30												x						
3325	Tschagan, USSR	51.17	91.32												x						
3329	Katon Karagai, USSR	49.00	85.40												x						
6691	Lapinjarvi, Finland																	x			
6692	Novo Liljanska, USSR	59.00	61.00															x			
7224	Ottawa, Ont.	45.25	75.43																	x	
7225	Ottawa, Ont.	45.25	75.43																	x	
7228	Ottawa, Ont.	45.25	75.43																	x	
7232	Ottawa, Ont.	45.25	75.43																	x	
7233	Ottawa, Ont.	45.25	75.43																	x	
7236	Ottawa, Ont.	45.25	75.43																	x	
7268	Solbole, Finland																			x	
7269	Punkaharju, Finland	61.43	29.25															x		x	
7270	Lapinjarvi, Finland																	x			
7271	Punkaharju, Finland	61.43	29.25															x			
7272	Ahtari, Finland	62.34	24.08															x			
7273	Punkaharju, Finland	61.43	29.25															x			
7274	Lapinjarvi, Finland																	x			
7275	Punkaharju, Finland																	x			
7276	Sverdlovsk, USSR	58.40	60.00															x			

Total 40 seedlots

5. L. GMELINI

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
222	Keijo, Japan			x																	
1615	Farum, Denmark	55.48	12.18			x	x	x	x												
1896	Dropmore, Man.	51.01	101.26			x															
2372	Sakhalin, USSR												x								
2640	Farum, Denmark	55.48	12.18			x									x						
2852	Chansi, China	39.30	113.30												x						
3328	Korsakov, USSR	46.42	142.50															x			
7408	P.N.F.I. Ont.	45.58	77.26																x		

Total 8 seedlots

6. L. OCCIDENTALIS

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	428
2563	B.C. Canada																				
2574	B.C. Canada														x						
7260	Ottawa, Ont.	45.25	75.43												x						
																					x

Total 3 seedlots

7. L. LARICINA

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	424
387	Oakpoint, NB			x																	
461	P.N.F.I. Ont.	45.58	77.26								x										
2077	P.N.F.I. Ont.	45.58	77.26								x										
2084	P.N.F.I. Ont.	45.58	77.26								x										
2118	Angus, Ont.	44.19	79.53								x										
2119	Bancroft, Ont.	45.03	77.52								x										
2120	Fort Smith, NWT	60.01	111.55								x										
7162-7169	P.N.F.I. Ont.	45.58	77.26														x				
7170-7175	Adelard, Ont.	46.13	78.01														x				
7177-7182	Sandlake Rd, Ont.	45.49	77.18														x				
7192-7211	P.N.F.I. Ont.	45.58	77.26														x				
8511-8515	Drumbo, Ont.	43.11	80.38																		x
8516-8518	Dunville, Ont.	42.55	79.30																		x
8519-8523	Glen Morris, Ont.	43.17	80.16																		x
8524-8528	Mossley, Ont.	42.56	81.03																		x
8530	North Pond, Nfld.	48.50	54.44																		x
8542	Meadow Lake, Sask.	53.50	108.40																		x
8543	Laronge, Sask.	55.24	104.58																		x
8544	Whitecourt, Sask.	54.05	115.30																		x
9301-9309	Lennoxville, Que.	45.21	71.50																		x
9310-9319	St Boniface, Que.	46.30	72.49																		x
9320-9329	St G. de Bradon, Que.	46.18	73.22																		x
9330-9339	St P. d'Ab'tsf'd, Que	45.26	72.52																		x
9340-9348	Drummondville, Que.	45.51	72.35																		x
9349-9351	La Tuque, Que.	47.26	72.47																		x
9352-9361	St M. des Sts., Que.	46.38	74.02																		x
9362-9368	Stonefield, Que.	45.37	74.35																		x
9369-9376	Lac des Écorces, Que.	46.33	75.28																		x
9377-9385	Otter Lk-K'bazua, Que	45.56	76.11																		x
9391	Riv. Bécancours, Que.	46.21	72.24																		x
9394-9400	Barrington, Que.	45.09	73.40																		x
9419-9423	Tennyson, Ont.	46.17	82.10																		x
9424	Keely Lake, Sask.	54.06	108.02																		x
9425	Hudson Bay, Sask.	53.01	102.01																		x
9426	McDowall, Sask.	53.06	106.00																		x
9427	Montreal Lake, Sask.	54.18	105.42																		x

7. L. LARICINA (contd.)

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB 13 35 64 65 66 67 90A 189 202 209 252 375 376 377 378 381 424
9428-9432	Eby-Burt Tp., Ont.	48.10	80.12	x
9433-9437	Gurd Tp., Ont.	46.00	79.40	x
9438-9442	Gillies L't Tp., Ont.	47.20	79.40	x
9443-9444	Dewart Tp., Ont.	48.50	94.15	x
9445-9449	Hendrie Tp., Ont.	46.15	80.30	x
9450-9455	Little Tp., Ont.	48.47	81.02	x
9456-9460	Vrooman Tp., Ont.	47.28	81.45	x
9482-9486	Matthiew Tp., Ont.	49.00	94.10	x
9487-9491	Sanford Tp., Ont.	49.50	93.10	x
9517-9518	McLean Tp., Ont.	45.10	79.07	x
9519-9523	Bobcaygeon Rd., Ont.	45.00	78.46	x
9524-9525	Glamorgan Tp., Ont.	44.58	78.23	x
9526	Dysart Tp., Ont.	45.01	78.27	x
9527-9531	Hagarty Tp., Ont.	45.34	77.24	x
9532-9543	Phelp's Tp., Ont.	46.25	79.08	x
9544-9553	Sapawe C.M.U., Ont.	48.45	91.20	x
9554-9563	Morly Tp., Ont.	48.42	94.10	x
9564-9573	Crooks Tp., Ont.	48.07	89.20	x
9574-9583	Wil'son-Dun. Tp., Ont	48.00	80.30	x
9584-9586	Tennyson Tp., Ont.	46.17	82.11	x
9587-9591	Manitouwadge, Ont.	48.45	85.50	x
9592-9601	Wainwright Tp., Ont.	49.53	92.52	x
9602-9604	Sioux Lookout, Ont.	50.00	92.00	x
9605-9614	Hurlbert Tp., Ont.	46.45	83.42	x
9615-9624	Ignace, Ont.	49.25	91.40	x
9625-9634	Oneida Co., Wisc.	45.38	89.23	x
9636	Cornwall dist., Ont.	45.12	75.04	x
9637	Robertson Lake, Ont.	45.12	76.36	x
9638	Oxford Tp., Ont.	44.55	75.39	x
9639	Carlsbad Springs, Ont.	45.22	75.28	x
9640	Gloucester Tp., Ont.	45.22	75.30	x
9641	Murray Tp., Ont.	44.12	77.44	x
9642-9644	Red Lake, Ont.	50.51	93.33	x
9645-9655	Lindsley Tp., Ont.	49.43	87.08	x
9656	Black Brook, NB	47.15	67.40	x
9657	Bathhurst, NB	47.29	65.36	x
9658	Shea Lake, NB	46.50	67.20	x
9659	Barberdam, NB	45.30	67.24	x
9660	Boisetown, NB	46.30	66.30	x
9661	Garden of Eden, NS	45.22	62.15	x
9662	Chignecto, NS	45.31	64.29	x
9663	Scotsburn, NS	45.44	62.53	x
9664	Stanley, NS	45.07	63.53	x
9665	Georgefield, NS	45.13	63.35	x
9666-9678	Deep River, Ont.	46.05	77.31	x

7. L. LARICINA (contd.)

Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB 13 35 64 65 66 67 90A 189 202 209 252 375 376 377 378 381 424
9679-9688	Moher Tp., Ont.	48.00	81.25	x
9689-9690	Slave Lake, Alta.	55.00	114.25	x
9691	Footner Lake, Alta.	53.31	118.00	x
9692	Whitecourt, Alta.	54.10	115.20	x
9693	Peace River, Alta.	56.28	116.43	x
9694	Raven, Alta.	52.05	114.28	x
20093-20102	Eby Tp., Ont.	48.05	80.10	x
20103-20111	Muskoka Airport, Ont.	44.58	79.30	x
20112-20122	Blackstock Tp., Ont.	48.18	80.50	x
20123-20132	Manitouwadge, Ont.	49.15	86.00	x
20133	Gloucester Tp., Ont.	45.20	75.27	x
20134	Dalhousie Tp., Ont.	45.04	76.33	x
20135-20144	Bearbrook, Ont.	45.20	75.28	x
20145-20156	Mahoney Hill Rd., ME	45.01	69.47	x
20157-20166	North Pond, Nfld.	48.43	54.33	x
20167-20168	Athabaska, Alta.	56.26	111.25	x
20179-20188	St. Magloire, Que.	46.35	70.18	x
20189-20198	Lac de l'Est, Que.	47.14	69.35	x
20199-20207	Ste.Rose-St.Louis, Que	46.19	70.26	x
20208-20217	St.Charles, Que.	46.47	70.57	x
20218-20224	Amqui, Que.	48.29	67.24	x
20225-20234	Squatec, Que.	47.55	68.44	x
20235-20239	Rap. des Joachim, Que	46.15	77.42	x
20240-20245	Lac Usborn, Que.	46.12	76.41	x
20246-20255	Kingsey Falls, Que.	45.52	72.03	x
20256-20265	Kinnear's Mills, Que.	46.12	71.19	x
20266-20275	Lac en Croix, Que.	46.32	74.22	x
20276-20285	Villeroy, Que.	46.24	71.55	x
20286	Dromore, PEI	46.16	62.52	x
20287	Lyndale, PEI	46.09	62.47	x
20288	North Enmore, PEI	46.36	64.03	x
20289	Porthill, PEI	46.34	63.52	x
20297-20300	Deep River, Ont.	46.05	77.31	x
20301-20306	Bear Brook, Ont.	45.20	75.27	x
20307-20310	Phelp's Tp., Ont.	46.25	79.08	x
20331-20341	Prince Albert, Sask.	53.16	105.32	x
20342-20352	Clear Sand S., Sask.	53.47	105.30	x
20353-20363	Anglin Lake, Sask.	53.47	105.49	x

Total 599 seedlots

8. LARCH HYBRIDS (other than L. x eurolepis).

Hybrid	Seedlot #	Origin	Lat.	Long.	Experiment numbers ARB	13	35	64	65	66	67	90A	189	202	209	252	375	376	377	378	381	424
sib x dec	2638	Horsholm, Denmark	55.48	12.18			x															
dec x sib	2639	Horsholm, Denmark	55.48	12.18			x															
gme x lep	2641	Horsholm, Denmark	55.48	12.18			x															
dec x occ	7218	Ottawa, Ont.	45.25	75.43																	x	
dec x dec	7219	P.N.F.I. Ont.	45.58	77.26																	x	
sib x dec	7221	Ottawa, Ont.	45.25	75.43																	x	
sib x dec	7222	Ottawa, Ont.	45.25	75.43																	x	
sib x lar	7223	Ottawa, Ont.	45.25	75.43																	x	
sib x dec	7226	Ottawa. Ont.	45.25	75.43																	x	
sib x dec	7227	Ottawa, Ont.	45.25	75.43																	x	
sib x dec	7229	Ottawa, Ont.	45.25	75.43																	x	
sib x dec	7230	Ottawa. Ont,	45.25	75.43																	x	
sib x lar	7231	Ottawa, Ont.	45.25	75.43																	x	
sib x dec	7234	Ottawa, Ont.	45.25	75.43																	x	
sib x dec	7235	Ottawa, Ont.	45.25	75.43																	x	
dec x lar	7237	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7238	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7239	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7241	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7242	P.N.F.I. Ont.	45.58	77.26																	x	
dec x occ	7247	Ottawa, Ont.	45.25	75.43																	x	
lep x dec	7250	Ottawa, Ont.	45.25	75.43																	x	
lep x dec	7254	Ottawa, Ont.	45.25	75.43																	x	
lep x dec	7255	Ottawa, Ont.	45.25	75.43																	x	
lep x sib	7265	Punkaharju, Finland	61.43	29.25																	x	
dec x dec	7398	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7399	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7405	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7406	P.N.F.I. Ont.	45.58	77.26																	x	
gme x dec	7409	P.N.F.I. Ont.	45.58	77.26																	x	
gme x dec	7410	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7412-7424	P.N.F.I. Ont.	45.58	77.26																	x	
dec x sib	7426	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7428	P.N.F.I. Ont.	45.58	77.26																	x	
dec x sib	7429	P.N.F.I. Ont.	45.58	77.26																	x	
dec x lep	7430	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7431	P.N.F.I. Ont.	45.58	77.26																	x	
dec x dec	7432	P.N.F.I. Ont.	45.58	77.26																	x	

Total 49 seedlots

Grand Total, all larch species and hybrids: 907 seedlots.

Notes: Most larch seedlots from Europe, with the exception of those from Poland, Czechoslovakia and Austria constitute selections in plantations. Many Japanese larch seedlots from Japan have a similar origin. All latitudes are North; all longitudes other than those for Scotland and North America are East. Hybrid abbreviations: dec = L. decidua; lep = L. leptolepis; sib = L. sibirica; lar = L. laricina; gme = L. gmelini; occ = L. occidentalis.

APPENDIX II

Larch experiments at PNFI

Note: The following abbreviations are used: op = open-pollinated families; cp = control-pollinated familes; OMNR = Ontario Ministry of Natural Resources.

EXPT. NO. AND DESCRIPTION: 13. Observation plot of Dunkeld hybrid of Japanese larch

LOCATION(S): Hudson's Place, PNFI

SITE DESCRIPTION(S): Fertile, well-drained sandy loam, water table at 1 m

DATE ESTABLISHED

Sown:	1926
Transplanted:	-
Planted:	1928 (2 + 0)
Spacing:	10' x 10'

DESIGN

Reps:	1
Plot type/size:	Block plot
Total # trees:	~400

MATERIAL: One seedlot from Atholl Estate, Scotland – seed collected from Japanese larch – mixture of pure species and *L. eurolepis* hybrid

DATA/MEASUREMENTS

Height:	Age 12, 40
Diameter:	Age 40
Damage:	Age 44

CURRENT STATUS: Severe early porcupine damage – phenotypically thinned in 1941 to 20 trees. Of these, 16 morphologically identified as hybrids and four as Japanese larch. These trees survive.

SUMMARY: Oldest hybrid larch plantation in North America

At age 40:	Height (m)		dbh (cm)	
	Mean	Range	Mean	Range
Japanese larch	15.0	14.3 - 16.5	32.0	26.4 - 37.6
Hybrid larch	19.9	16.2 - 23.2	37.0	31.8 - 42.7

H_0: Species' heights equal: $t = 4.82^{**}$
H_0: Species' diameters equal: $t = 2.39^{*}$
Ref: Holst (1974)

EXPT. NO. AND DESCRIPTION: 35-A. Comparison of European and Japanese larch and their hybrids

LOCATION(S): McDonald's Field East (PA105), PNFI

DATE ESTABLISHED

Sown: 1949/1951
Planted: 1953

DESIGN

Reps: 1
Plot type/size: Blocks of ranging sizes
Total # trees: 3267

MATERIAL: Six op families and nine provenances of *L. decidua*; three op families of *L. leptolepis*; one op family of *L. eurolepis*; two seedlots of *L. gmelini*; two seedlots of *L. sukaczewii*

DATA/MEASUREMENTS

Height: 1965, 1979 } before and after thinning
Diameter: 1965, 1979 }
Survival: 1965
Other: Lean, 1965

CURRENT STATUS: The plantation was phenotypically thinned in 1965, removing approximately 30% of the trees, and again in 1979. 384 trees remained.

Expt. 35-A – Comparison of larch species and hybrids

Seedlot	Description	Height (m)		Diameter (cm)	
		1965	1979	1965	1979
1412	*L. decidua* op family from Danish selection	7.8		11.0	24.4
1413	*L. decidua* op family from Danish selection	7.8	14.5	10.3	22.0
1605	*L. decidua* op family from Danish selection	8.3	13.0	10.3	20.8
1606	*L. decidua* op family from Danish selection	8.4	15.7	11.1	23.5
1607	*L. decidua* op family from Danish selection	7.5	15.3	8.6	17.3
1608	*L. decidua* op family from Danish selection	8.3	15.1	8.7	19.4
1337	*L. decidua* Sudeten Mtns, Czechoslovakia	8.7	17.4	8.7	21.0
1608	*L. decidua* Sudeten Mtns, via Denmark	8.7	17.0	8.5	20.1
1620	*L. decidua* Kronborg, Skov, Denmark	7.6	16.7	7.3	18.7
1619	*L. decidua* Noedebo, Denmark	8.2	16.6	7.4	17.5
1616	*L. decidua* Farum Skov, Denmark	7.4	16.2	6.9	17.1
1621	*L. decidua* Jaegersborg Hegn, Denmark	7.4	16.0	6.9	16.9
1617	*L. decidua* Farum Skov, Denmark	7.2	17.0	6.7	16.0
1623	*L. decidua* Lellinge, Denmark	6.9	15.7	5.8	13.3
1622	*L. decidua* Gurre Skov, Denmark	7.2	15.0	6.2	13.7
1609	*L. leptolepis* op family from Danish selection	6.2		7.0	16.3
1610	*L. leptolepis* op family from Danish selection	7.6		10.0	25.0
1611	*L. leptolepis* op family from Danish selection	7.5		9.8	24.7
1612	*L. eurolepis* op family from Danish selection	6.8	13.9	7.8	19.3
1615	*L. gmelini* Kankyo-Hokudo, Korea via Denmark	7.4	14.2	7.8	16.8
1819	*L. kurilensis* via Manitoba	5.6		5.3	
1613	*L. sukaczewii* via Denmark	8.3	17.1	9.5	22.0
1895	*L. sukaczewii* via Manitoba	4.1		3.2	

SUMMARY: Open-pollinated families from Danish selections of *L. decidua* were much taller and had a greater dbh than the provenance samples in 1965, but the provenances were taller by 1979 (16.4 m vs. 14.7 m).
A seedlot of *L. sukaczewii* via Denmark (17.1 m in 1979) was taller than all other seedlots except one of *L. decidua* from the Sudeten Mountains, Czechoslovakia, which was 2 years older.
Table on previous page gives 1965 and 1979 data.

EXPT. NO. AND DESCRIPTION: 35-B. Observation plot of Korean larch

LOCATION(S): Meridian Road (PA101), PNFI

SITE DESCRIPTION(S): Level, sandy

DATE ESTABLISHED

Sown:	1959
Transplanted:	1961
Planted:	1962
Spacing:	6' x 8', total area 0.2 ha

DESIGN

Reps:	1
Plot type/size:	Block
Total # trees:	50

MATERIAL: One seedlot of *L. koreensis* via Denmark

CURRENT STATUS: Some trees still surviving.

EXPT. NO. AND DESCRIPTION: 35-C. Comparison of larch hybrids

LOCATION(S): Fuelwood Area (PA114), PNFI

SITE DESCRIPTION(S): Moist, with rocky and wet patches

DATE ESTABLISHED

Sown:	1959
Planted:	1962
Spacing:	6' x 6'

DESIGN

Reps:	1
Plot type/size:	Block plots of varying sizes
Total # trees:	1326

MATERIAL: Two op families of *L. decidua* x *sibirica* (from Denmark); one op family of *L. gmelini* x *leptolepis* (from Denmark); one op family of *L. laricina* "hybrid" (from Denmark)

EXPT. NO. AND DESCRIPTION: 64-A,B,C. Comparison of larch species and provenances

LOCATION(S): Rose Twp., Ont./Cochrane, Ont./Maple, Ont.

DATE ESTABLISHED Planted: 1957

CURRENT STATUS: closed/dormant

EXPT. NO. AND DESCRIPTION: 66. Comparison of Siberian and (Polish) European larch

LOCATION(S): Kapuskasing, Ont.

SITE DESCRIPTION(S): Dry, strong grass competition

DATE ESTABLISHED

Sown:	1945 and 1952 (*L. sibirica*); 1951 and 1953 (*L. decidua*)
Transplanted:	1948
Planted:	1951 and 1956
Spacing:	?

DESIGN

Reps:	1
Plot type/size:	Block plots, of varying size
Total # trees:	approx. 700

MATERIAL: Two seedlots of *L. sibirica* via Finland; three seedlots of *L. decidua* from Denmark; one seedlot of *L. decidua* from Pienny Mtns., Poland; one seedlot of *L. gmelini* var. *olgensis* (died in nursery beds)

DATA/MEASUREMENTS

Height:	1985	} sample trees
Diameter:	1985	

CURRENT STATUS: Survival and growth good; some *L. sibirica* have cracked stems

SUMMARY: *L. sibirica* more productive than *L. decidua*. For example *L. sibirica* was 13.8 m tall, 21.7 cm dbh in 1985 vs. 12.1 m and 19.7 cm for *L. decidua*.

EXPT. NO. AND DESCRIPTION: 67-A to H. Provenance trials of European larch in the Great Lakes States, New England, and New York.

LOCATION(S): Ripco, WI/Ithaca, NY/ Warsaw, WI/ Stephenton, NY/Rochester, NY/Hillsboro, NH/East Nassau, NY

DATE ESTABLISHED Planted: 1956

CURRENT STATUS: Closed/dormant

EXPT. NO. AND DESCRIPTION: 90-A and 100. Comparison of larch species and hybrids

LOCATIONS(S): Fuelwood Area (PA114), PNFI

DESIGN

Reps: 1
Plot type/size: Row plots of ranging sizes

MATERIAL: Four seedlots of *L. decidua*; three op and two cp families of *L. eurolepis*; one seedlot of *L. sibirica*; three seedlots and one op family of *L. laricina*

DATA/MEASUREMENTS

Height: Age 2, 12, 24, 28 — *L. laricina* only at age 24; not all seedlots at age 28

Diameter: Age 12, 24, 28

SUMMARY: *L. laricina*, Polish *L. decidua*, and *L. eurolepis* tallest at age 28 (15 cm). *L. sibirica* significantly shorter and smaller dbh than other species/hybrids. Table attached.

Results of Expts. 90A and 100

Expt., Seedlot		1956	1966				1978		1982		
		Height	Height (m)	dbh (cm)	MAHG (cm)	Surv. (%)	Height (m)	dbh (cm)	Height (m)	dbh (cm)	MAHG (cm)
	1711 *L. sibirica* Finland		3.60	4.3	25.7				10.31 C (2.29)	15.2 D 95.3)	34.4
	1886 *L. decidua* Austria		5.56	7.0	42.8				12.75 BC (1.88)	16.8 CD (5.1)	44.0
	1887 *L. decidua* Austria		5.30	6.5	40.8				13.83 AB (2.83)	18.1 BC (5.8)	47.7
90-A	1894 *L. decidua* Poland		7.22	7.2	60.2				14.73 A (3.02)	18.4 B (4.8)	52.6
	1084 *L. laricina* PNFI		8.01	8.2	66.8		13.60	15.8			
	2118 *L. laricina* Angus, Ont.		7.17	6.8	59.8		12.70	13.9			
	2119 *L. laricina* Bancroft, Ont.		7.19	7.3	59.9		13.70	16.7			
	2145 *L. decidua* Poland		7.58	8.8	63.2				15.56 A (2.74)	20.1 AB (4.9)	55.6
	2072 *L. eurolepis* ST. 496 x 498		7.45	10.8	62.1						
	2073 *L. eurolepis* ST. 497 x 498		6.82	10.1	56.8						
100	2074 *L. eurolepis* ST. 495 OP		5.95	7.9	49.6				14.73 AB (2.80)	21.1 A (4.4)	52.6
	2075 *L. eurolepis* ST. 496 OP		6.51	8.3	54.3						
	2076 *L. eurolepis* ST. 497 OP		6.67	8.0	55.6						
	2077 *L. laricina* ST. 499 OP		7.75	8.3	64.6		12.60	17.7	15.17 A (1.68)	16.9 BCD (3.9)	54.2

Notes: Height in metres; dbh = Diameter breast height in cm; MAHG = Mean annual height growth in metres; Surv. = survival in %.
Figures in parentheses are standard deviations; letters represent groups of homogenous means (at 5% level) according to Bonferroni's t-test.

EXPT. NO. AND DESCRIPTION: 90-B. Provenance trial of European larch and comparison with tamarack grafts.

LOCATION(S): Arbour's Field (PA119), PNFI

DATE ESTABLISHED

Sown: 1954 (scions grafted in 1953)
Transplanted: 1955
Planted: 1958 (1 + 3)
Spacing: 6′ x 6′

DESIGN

Reps:	1
Plot type/size:	Block plots of variable size
Total # trees:	1177

MATERIAL: Two Austrian (Paternion & Rosalia) and one Polish (Krakow) seedlots of *L. decidua*. Three clones of *L. laricina* from Mattawa, Ont.

DATA/MEASUREMENTS Height: Age 12

CURRENT STATUS: Plantation abandoned

EXPT. NO. AND DESCRIPTION: 189. Observation plot of (Polish) European larch

LOCATION(S): Harrington, Forest Farm, Aurora, Québec

DATE ESTABLISHED

Sown:	1954
Transplanted:	1956
Planted:	1958

DESIGN

Reps:	1
Plot type/size:	Single block

MATERIAL: Seedlot 1894, Pienny Mtns, Poland

DATA/MEASUREMENTS

Height:	Age 17
Diameter:	Age 17
Survival:	Nursery

CURRENT STATUS: Commercial plantation

SUMMARY: Only 37.5% survival at lifting (weed problem). 11.8 m tall and 16.8 cm dbh at age 17. Locally planted Japanese and hybrid larch more productive.

EXPT. NO. AND DESCRIPTION: 202-A. Test of Polish seed sources

LOCATIONS(S): AECL plantation

SITE DESCRIPTION(S): Loamy sand (non-calcareous) with podzol. Gentle undulating terrain.

DATE ESTABLISHED

Sown:	Spring 1957
Transplanted:	1958
Planted:	Spring 1960
Spacing:	1.8 x 1.8 m

DESIGN

Reps:	4
Plot type/size:	square 100-tree plots
Total # trees:	3800 (400/prov. + 1 prov. with 1400 trees)

MATERIAL: Seven provenances: five Polish, one Japanese (*L. gmelini* var. *japonica*), and one from the Alps via Farum (Denmark).

DATA/MEASUREMENTS

Height:	10, 14, 21, 28. Partial measurements except for age 18.
Diameter:	14, 21, 28. Runts rejected
Survival:	good (90%) for all but the Japanese source (45%)
Sawfly defoliation:	1977

CURRENT STATUS: Selective thinnings in 1966, 1970, and 1984, leaving approx. 150 trees per seedlot in 1984. Trial still in good condition.

SUMMARY: The Blizyn source (S2498) was consistently among the tallest sources throughout this experiment (age 10 = 4.6 m, age 14 = 8.5 m, age 21 = 13.1 m, age 28 = 18.1 m, CV%~15%). The second best source was Mala Wies (Poland) which was non-significantly different from Blizyn. The Japanese source (S2372, Sakhalin) had inferior growth (age 28 = 12.3 m or 32% less than the Polish sources). The Alpine larch imported through Farum in Denmark ranked as number 6. Age-to-age correlations (i.e. rank stability) was high throughout this experiment (>0.8). All European seedlots were significantly taller than the Japanese source at age 28. The tallest source (Blizyn) was significantly taller than Kroscienko and the Sakhalin source only. All seedlots were defoliated by the sawfly. The Danish source was least susceptible. Correlations of defoliations with height were not significant.

EXPT. NO. AND DESCRIPTION: 202-B, C, D, E, F, H, I, K. Comparison of larch species

LOCATION(S): West Milton, NY/Durling Fields, NS/ Richmond Hill, Ont./Fredericton, NB/Syracuse, NY/Acadia, NB/Eganville, Ont./Hull, Que./Harrington, Que

DATE ESTABLISHED Planted: 1959/60

CURRENT STATUS: Closed/dormant

EXPT. NO. AND DESCRIPTION: 202G-1. European larch from Poland and the Alps via Denmark.

LOCATION(S): Harrington Forest Farm, Grenville, Québec. (Co-op with CIP)

SITE DESCRIPTION(S): Sandy loam, sloping hill with western exposure

DATE ESTABLISHED

Sown:	1957
Transplanted:	1959
Planted:	1960
Spacing:	2.5 x 2.5 m

DESIGN

Reps:	4
Plot type/size:	100-tree plots (5 x 20)
Total # trees:	2400 exp. plants

MATERIAL: Polish sources: Wroclaw, Blizyn, Kroscienko, Krojic Skarzysko. Alpine source: 'Farum' (Denmark)

DATA/MEASUREMENTS: Height: 10, 20 (complete in 1967, partial (20 best) in 1977)
Diameter: 10, 20
Survival: poor at age 10 average was 45%

CURRENT STATUS: Too low survival to warrant future measurements

SUMMARY: The Blizyn source was tallest at age 10 and again at age 20 (Av. = 3.0 m at age 10 (CV = 29%), and 12.6 m at age 20 (CV = 8%). Poorest height growth was the Alpine source imported via Denmark (11% shorter than Blizyn). No statistically significant seedlot effects were noted ($0.5 < P < .15$).

EXPT. NO. AND DESCRIPTION: 202-J. Provenance trial of Polish and Danish European larch

LOCATION(S): Fuelwood Area (PA114), PNFI

MATERIAL: Five provenances of Polish *L. decidua*; one provenance of Danish *L. decidua*

DATA/MEASUREMENTS Height: Age 7 (two seedlots only), 22
Diameter: Age 7 (two seedlots only), 22

SUMMARY: Polish provenances significantly taller than Danish provenance, but no significant difference for dbh.
Best provenances: Skarzysko and Blizyn (15.2 m at 22 years).
Table attached.

Results of Expt. 202-J
Observation Provenance Trial of Polish European Larch

Seedlot		1967			1982		
		Height (m)	dbh (cm)	MAHG (cm)	Height (m)	dbh (cm)	MAHG (cm)
2316	*L. decidua* Wroclaw, Poland				14.31 AB (1.72)	15.1 B (3.0)	57.2
2498	*L. decidua* Blizyn, Poland				15.18 A (2.11)	16.8 A (4.2)	60.7
2499	*L. decidua* Kroscienko, Poland				12.39 C (2.52)	13.8 C (3.8)	49.6
2500	*L. decidua* Mala Wies, Poland				13.75 B (2.28)	17.1 A (4.3)	55.0
2501	*L. decidua* Skarzysko, Poland	5.57 (1.13)	6.4 (1.8)	55.7	15.17 A (2.18)	17.5 A (3.7)	60.7
2502	*L. decidua* Farum, Denmark	4.17 (0.98)	4.6 (1.6)	41.7	13.62 BC (2.01)	16.5 A (3.1)	54.5

Notes: Height in metres; dbh = Diameter breast height in cm; MAHG = Mean annual height growth in metres; Surv = survival in %. Figures in parentheses are standard deviations; letters represent groups of homogenous means (at 5% level) according to Bonferroni's t-test.

EXPT. NO. AND DESCRIPTION: 209-A. Provenance exp. with European and hybrid larch. (see 209e)

LOCATION(S): AECL

SITE DESCRIPTION(S): Old farmland, loamy sand (podzol)

DATE ESTABLISHED Sown: 1958
Planted: Spring 1961
Spacing: 1.2 x 1.2 m

DESIGN

Reps:	4
Plot type/size:	10 x 10 tree square plots
Total # trees:	2800 exp. plants; 400 per seedlot

MATERIAL: Seven seedlots European: Rosalia (Austria), Zagnansk (Poland), Muszyna (Poland), 3 Alpine via Denmark, Schlitz (Germany). Hybrid: imported from Denmark

DATA/MEASUREMENTS

Height:	9, 13, 20, 22, 27 (10 trees/rep)
Diameter:	13, 20, 22, 27 (10 - /rep)
Survival:	good (at age 9) 95% (no seedlot effects)
Sawfly defoliation:	1977

CURRENT STATUS: Experiment selectively thinned in 1966, 1970, and 1980 (pulping results from thinning on file), leaving approx. 80 trees per seedlot. The trial is in good condition and should be maintained as a source of candidates for future breeding.

SUMMARY: The hybrid and polish source form Muszyna were superior in height in all but the first measurement. The mean heights of the hybrid were 4.9 m (age 9), 9.5 m (age 13), 13.6 m (age 20), 14.9 m (age 22), 17.9 m (age 27). The seedlot was significantly better than the poorest performer from Austria (Rosalia) which grows about 22% less than the only hybrid source. Rank stability was high after the first measurement (.85) and reliable predictions can be made early. Diameter results reflected by and large those of height. Correlation between defoliation and height (0.58) was significant.

EXPT. NO. AND DESCRIPTION: 209-B-1. European hybrid and Japanese larch (Co-op with CIP. See also 209-B-2)

LOCATION(S): Harrington Forest Farm, Aurora, Québec

DATE ESTABLISHED

Sown:	1957
Transplanted:	1959
Planted:	1960
Spacing:	2.5 x 2.5 m

DESIGN

Reps:	3
Plot type/size:	100-tree plots (5 m x 20 trees)
Total # trees:	2700

MATERIAL:
Austrian larch (Rosalia, Paternion), Japanese v. Denmark
"Tatra larch" (Muszyna), hybrid v. Denmark
Polish larch (Zagnansk)
Alpine v. Denmark (Rundforbi, Farum)
German larch (Schlitz)

DATA/MEASUREMENTS:

Height:	10, 20 (max. 20 trees per plot)
Diameter:	10, 20
Survival:	age 10: low; avg. = 35%. Japanese 1% surv. Rest ≈ 40% with no effects
Damage:	frost

CURRENT STATUS: Mortality has reached an intolerable level and no further assessments should be made. (In some seedlots only five trees remain per plot)

SUMMARY: The Japanese source did not survive (1% survival) in this continental and harsh climate. The best seedlot was the Schlitz (Germany) which averaged 13 m at age 20 and 3.4 m at age 10. The three poorest seedlots were from Austria and, of course, from Japan. All other seedlots except the Alpine v. Farum in Denmark were significantly taller than these three seedlots. No significant (P = 0.05) difference averaged among the remaining five best seedlots. Height range age 20 (12.3 - 13.0 m CV% = 12%). Similar conclusions were drawn from the 10 years' measurements. Diameters were reflections of heights (≈ 18 cm at age 20 for the best five seedlots).

EXPT. NO. AND DESCRIPTION: 209-B-2 (see also 209-B-1). European and Japanese larch. (Co-op with CIP).

LOCATION(S): Harrington Forest Farm, Aurora, Québec.

DATE ESTABLISHED

Sown:	1957
Transplanted:	1959
Planted:	1960
Spacing:	2.5 m x 2.5 m

DESIGN

Reps:	3
Plot type/size:	100-tree plots (5 x 20)
Total # trees:	9 x 3 x 100 = 2700 exp. plants

MATERIALS: see 209B1

DATA/MEASUREMENTS

Height:	10, max. 20 trees/rep. measured
Diameter:	10
Other:	basal sweep of stem (classes)

CURRENT STATUS: unknown

SUMMARY: Good height growth of Zagnansk (Poland) seedlot (2.7 m at age 10) followed by Muszyna (Poland) with 2.6 m (CV% = 30%). Poorest growth in the two Austrian sources (1.9 m - 1.7 m) and a near complete loss of the Japanese source (7% survival). The Polish and German sources were significantly (P=0.05) taller than the Austrian and Japanese sources. The Alpine and hybrid seedlots were significantly taller than the slowest-growing seedlot from Paternion (Austria). No significant differences were seen in the basal sweep results. Diameters followed trends outlined for height.

EXPT. NO. AND DESCRIPTION: 209-F (1 + 2). Provenance test of European, Japanese, and hybrid larch (see also 209a and 209e).

LOCATION(S): AECL (plantation 124)

SITE DESCRIPTION(S): One dry (high) and one wet (low). pH ~ 5-5.5 with no difference between sites. Sandy loam, good drainage on hill. Podzol with thin organic horizons (AH and A2). Parent material: glacial till.

DATE ESTABLISHED

Sown:	1958
Transplanted:	1959
Planted:	Spring 1961
Spacing:	1 x 1.8 m (stock 2-1)

DESIGN

Reps:	Two per site
Plot type/size:	30-tree rows (design changes between sites)
Total # trees:	1913 exp. plants + surround rows

DATA/MEASUREMENT

Height:	9, 13, 20, 22 (complete), runts rejected
Diameter:	13, 20, 22
Survival:	At age 9 good on dry site (95%), worse on wet site (80%). Significant site and seedlot differences. "Tatra" (Muszyna) and Japanese had best survival, hybrid poorest.

CURRENT STATUS: Thinnings in 1970 and 1981 selectively removed 4-100 trees per seedlot (more on dry site).

SUMMARY: Site differences became highly significant from age 13 onwards. Dry › wet by 20-25% in all years. Site x seedlot effects not significant (P > .25). Seedlot effects highly significant all years. Best height obtained with the hybrid and poorest with Zagnansk (Poland). All seedlots except Zagnansk (Poland) were significantly higher than Austria. Also, Muszyna (Poland) and "Farum", Denmark were significantly taller than the Austrian source. Rank stability was very good and no systematic rank changes were observed. At age 22 the height of the hybrid averaged 1.57 m (± 1.0 m) composed to 11.8 m in the Austrian source. Diameters followed tree height.

EXPT. NO. AND DESCRIPTION: 209-C, D, I. Comparison of European, Japanese, and hybrid larch provenances

LOCATION(S): Univ. of Toronto/Acadia, NB/Fort Frances, Ont.

DATE ESTABLISHED Planted: 1962

CURRENT STATUS: Closed/dormant

EXPT. NO. AND DESCRIPTION: 209-E. Provenance study with European, Japanese, and hybrid larch

LOCATION(S): AECL (Plantation 123)

SITE DESCRIPTION(S): Old farmland cleared of sweetfern prior to planting

DATE ESTABLISHED

Sown:	1958
Planted:	Spring 1961
Spacing:	1.8 x 1.8 m

DESIGN

Reps:	Unreplicated
Plot type/size:	30-40 tree row plots, 2-8 rows/prov.
Total # trees:	1150

MATERIAL: Three European: Rosalia (Austria), Zagnansk (Poland), Alpine v. Rundforbi (Denmark); two Japanese v. Denmark; one hybrid v. Denmark

DATA/MEASUREMENTS

Height:	9, 13, 21 (runts rejected)
Diameter:	13, 21
Survival:	93% at age 9

CURRENT STATUS: Selectively thinned in 1970 and 1980 leaving 322 trees standing. The number of hybrid trees left is too low for objective evaluations.

SUMMARY: A good demonstration plot of how silvicultural treatment/selection in Denmark has modified the expected ranking of natural provenances. Best results obtained with the European larch from "Rundforbi" in Denmark. Its height of 14.9 m (± 0.2) at age 21 confirms the potential of this species. The hybrid larch ranked second and the Austrian source last (with a height 20% less than the best). Diameter results essentially confirmed height results. Rank stability over time was very strong.

EXPT. NO. AND DESCRIPTION: 209-H. Trial of western larch

LOCATION(S): Fuelwood Area (PA114), PNFI

SITE DESCRIPTION(S): Fresh loam, gently sloping

DATE ESTABLISHED

Sown:	1958
Transplanted:	1959
Planted:	1961 (1 + 2)
Spacing:	8′ x 8′

DESIGN

Reps:	1
Plot type/size:	Blocks, variable size
Total # trees:	164

MATERIAL: Two seedlots of *L. occidentalis*, from British Columbia but of unknown origin

DATA/MEASUREMENTS

Height:	Age 13
Survival:	Age 13

CURRENT STATUS: Three trees survive

SUMMARY: At age 13:

Seedlot	Height(m)	Survival(%)
2563	1.84	7.1
2574	2.10	5.8

- very poor growth and survival

EXPT. NO. AND DESCRIPTION: 224. Trial of "authentic" Japanese larch in eastern Canada

LOCATION(S): Acadia Forest Experiment Station, NB.

SITE DESCRIPTION(S): none

DATE ESTABLISHED

Sown:	1959
Transplanted:	1961
Planted:	1962
Spacing:	10' x 10'

DESIGN

Reps:	3
Plot type/size:	5 x 5 balanced lattice square. 49 trees/plot
Total # trees:	3675

MATERIALS: 20 Japanese larch seedlots
3 European larch seedlots
2 tamarack seedlots

CURRENT STATUS: Unknown

SUMMARY: Seed obtained from Syracuse University, NY. Some seedlots sown Denmark, Sweden, West Germany, New York. Seed sent by M. Holst to Maritimes Forestry Centre, Fredericton, N.B.

EXPT. NO. AND DESCRIPTION: 252-A. European larch provenance test from Czechoslovakia and via Denmark

LOCATION(S): Fuelwood Area (PA114), PNFI

SITE DESCRIPTION(S): Sandy loam mixed with boulders and gravel. Gently rolling with good drainage, pH 5.45.

DATE ESTABLISHED

Sown:	1962
Transplanted:	1964
Planted:	1966
Spacing:	1.8 x 1.8 m

DESIGN

Reps:	10
Plot type/size:	row plot/10 trees per plot
Total # trees:	900 experimental trees/276 surround/total 1176

MATERIAL: Seven seedlots from Czechoslovakia and two via Denmark
2655 - Ganlose Ore, Denmark 2848 - Trencin

2656 - Farum District
2845 - Sabinov Czech.
2846 - Frnov Radin
2847 - Parsovile
2849 - Tatranska Lomnica
2850 - Cierny Vah
2851 - Cervena Skala

DATA/MEASUREMENTS

Height:	1968, 76, 83
Diameter:	1983
Survival:	1969
Damage:	Winter burn - summer 1970

CURRENT STATUS: Plantation was thinned in 1983.

SUMMARY: Survival for all provenances very high (<80%) from 1968 measurement through to 1983. All measurements show no significant differences at 5% level for height or diameter. However, at age 7 years the sources via Denmark were better than the Czechoslovakian sources. Based on 1983 heights, S2846 ranked first, had the highest survival, and was most frost hardy in 1969. Lowest survival after 8 years was 86%.

EXPT. NO. AND DESCRIPTION: 252-B. Botanical collection of *Larix* species

LOCATION(S): Fuelwood Area (PA114), PNFI

SITE DESCRIPTION(S): Sandy loam mixed with boulders and gravel, variable

DATE ESTABLISHED

Sown:	1962
Transplanted:	1964
Planted:	1966
Spacing:	10′ x 10′

DESIGN

Reps:	1
Plot type/size:	Observation, variable plot size
Total # trees:	400 (.04 ha)

MATERIAL: 23 seedlots of *Larix koreensis, L. gmelini, L. decidua, L. leptolepis, L. sibirica*

DATA/MEASUREMENTS

Survival:	1970
Other:	1970 Frost Ratings

CURRENT STATUS: Active

SUMMARY: Observation trial of survival and growth of different *Larix* species

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EXPT. NO. AND DESCRIPTION: 252-C. Demonstration of larch species and hybrids

LOCATION(S): PNFI Pine Graft Arboretum PA 145, Cottage Rd. - HQ Road

SITE DESCRIPTION(S): Loamy sand with small gravel

DATE ESTABLISHED

Sown:	1977
Transplanted:	1978
Planted:	1980
Spacing:	5 m x 5 m

DESIGN

Reps:	Demonstration
Plot type/size:	5 x 9 tree plots
Total # trees:	45 trees

MATERIAL: Five seedlots. *Larix laricina*, L. *decidua*, *L. leptolepis*, and *L. eurolepis*

SUMMARY: Demonstration of hybrid vigour.

EXPT. NO. AND DESCRIPTION: 375-A. Trial of eight seedlots of Japanese larch from Japanese and European stands and seed orchards

LOCATION(S): PNFI. Pine Graft Arboretum PA115

SITE DESCRIPTION(S): Former hardwood site, sandy-loam, drainage toward west

DATE ESTABLISHED

Sown:	1972
Transplanted:	1974
Planted:	1976
Spacing:	1.2 x 1.2 m

DESIGN

Reps:	10
Plot type/size:	8 seedlots; 10 tree row plots
Total # trees:	800 experimental plants 280 surround plants - double row

MATERIAL: Eight seedlots from Japan; two via Scotland

DATA/MEASUREMENTS

Height:	1982, 1987
Damage:	Frost damage 1977

CURRENT STATUS: Survival for this test of *Larix leptolepis* is very poor. For the 1987 measurements of height, blocks 1, 2, and 6 were measured - the rest were eliminated because few trees remained.

SUMMARY: Based on three replications, heights ranged from max. 7.76 m to min. 6 m. No significant differences between seedlots based on height in 1987. Survival over three replications was ≈ 55%. Ranging from six trees out of 30 to 26 out of 30. S.6844 had highest survival but ranked lowest for height.

EXPT. NO. AND DESCRIPTION: 376-A-1-1, 2, 3; 376-A-2. Open-pollinated family tests of tamarack

LOCATION(S): PNFI. Pine Graft Arboretum 104, 115, 131

SITE DESCRIPTION(S): Sandy/sandy loam sites, dry to moist

DATE ESTABLISHED

Sown:	1971
Transplanted:	1973
Planted:	1974
Spacing:	2m x 2m

DESIGN

Reps:	variable
Plot type/size:	5 tree row
Total # trees:	1500-3500

MATERIAL: 36 open-pollinated families from five populations in the Ottawa Valley

DATA/MEASUREMENTS:

Height:	1975, 1976, 1977, 1980, 1984, 1987
Diameter:	1987
Survival:	1975, 1976, 1977, 1980, 1984, 1987
Damage:	1987

CURRENT STATUS: Good survival except in some replications of 376A12. Some porcupine damage.

SUMMARY: Highly variable performance on different sites and no significant variation among families from most populations. Frequency of most stem defects acceptably low (~5%).

EXPT. NO. AND DESCRIPTION: 376-B. Open-pollinated family test of tamarack.

LOCATION(S): German Democratic Republic

CURRENT STATUS: Unknown

EXPT. NO. AND DESCRIPTION: 376-C. Open-pollinated family test of tamarack.

LOCATION(S): Sweden

CURRENT STATUS: Unknown

EXPT. NO. AND DESCRIPTION: 376-D. Open-pollinated family test of tamarack.

LOCATION(S): Lotbinière and Bonaventure, Québec

CURRENT STATUS: Unknown

EXPT. NO. AND DESCRIPTION: 376-E. Open-pollinated family test of tamarack.

LOCATION(S): Ottawa, Ont.

CURRENT STATUS: Unknown

EXPT. NO. AND DESCRIPTION: 376-F. Open-pollinated family test of tamarack.

LOCATION(S): Rhinelander, WI, USA

CURRENT STATUS: Unknown

EXPT. NO. AND DESCRIPTION: 377-A-1. Comparison of various Siberian larch hybrids consisting of 11 seed sources: two Siberian larch provenances from U.S.S.R., two improved lots of Raivola origin, five seedlots from Finnish clone bank, and two Finnish arboretum lots containing hybrids (mixed).

LOCATION(S): PNFI. Pine Graft Arboretum PA115

SITE DESCRIPTION(S): Former hardwood site, sand loamy soil

DATA ESTABLISHED

Sown:	1972
Transplanted:	1974
Planted:	1976
Spacing:	2.1 x 2.1 m

DESIGN

Reps:	5
Plot type/size:	10 tree row plot
Total # trees:	550 experimental plants 225 surround plants

MATERIAL: 11 Siberian larch and hybrids seedlots

S.6692, S-7276	Siberian larch USSR
S.7268, S.6691	Raivola improved Siberian larch
S.7269, S.7270, S.7271, S.7272, S.7273	Selected hybrids from Finnish clone bank (Raivola)
S.7274, S.7275	Arboretum seedlots (Finnish) (mixed hybrids)

DATA/MEASUREMENTS Height: 1982, 87

CURRENT STATUS: Survival very low. Due to 1) slow growth of Siberian larch and 2) site conditions - suppression due to herb and brush. Cleared 1988.

SUMMARY: Survival in 1987 was very low (40%). Only 11% of the trees were >3 m and measured. Group of five seedlots selected from the clone bank at Punkaharju Exp. Forest had highest survival of 20% for the group and mean height of 4.45 m at age 15 years. S.7273 - Irkutsk had best survival and best height.

EXPT. NO. AND DESCRIPTION: 378-A. Trial of European x Japanese larch hybrids

LOCATION(S): Portage du Fort, Quebec.

DATE ESTABLISHED

Sown:	1974
Transplanted:	1975
Planted:	1977
Spacing:	3 x 1.5 m

DESIGN

Reps:	8
Plot type/size:	2 x 5 trees
Total # trees:	1536 plants

MATERIAL:

5 Alpine x Japanese larch
3 Sudeten x Japanese larch
1 Polish x Japanese larch
7 European larch (general collections via Denmark, Germany, Sweden, Quebec)
4 Japanese, 1 *Larix laricina* (PNFI)

DATA/MEASUREMENTS

Height:	7, 13
Diameter:	13
Survival:	good (85% in 1981, 71% in 1987)
Damage:	Porcupine, drought in year of planting

CURRENT STATUS: A well-designed experiment in good conditions. Good source for scion collections from outstanding trees

SUMMARY: The tallest seedlot in 1987 was the hybrid (S7310) between Alpine and Japanese (imported through Gavnø-Lindersvold, Denmark). Height (age 13): 10.3 m (± 7%), dbh = 14 cm (± 20%). This seedlot was significantly taller than the local tamarack (h = 7.6 m at age 13) and also significantly taller than the Japanese seedlot S7304 (via GDR) and European seedlots 7475 imported through Quebec. Significant rank changes occurred between ages 7 and 13. The best 1987 seedlot ranked only 8th in 1981 and the local tamarack dropped from a rank 10 to bottom rank 20 in 1987. The hybrid (7302) between Polish and Japanese larch ranked a number 1 or 2 in both years. Stem form varied significantly among seedlots ($P<0.01$). Tamarack and nine other seedlots had more than 20% of their trees categorized as crooked. The tallest seedlot was also among the best formed. Porcupine attacks were clustered in few seedlots but no obvious preference pattern emerged.

EXPT. NO. AND DESCRIPTION: 378-D. To determine the relative performance of various kinds of European x Japanese larch hybrids

LOCATION(S): Unknown - seed sent to Ministère de l'énergie et des ressources, Quebec

DATE ESTABLISHED Sown: 1973

SUMMARY: Only information: sowing 1973

EXPT. NO. AND DESCRIPTION: 379. Seed orchard/clonal test of European larch from Poland

LOCATION(S): PNFI

CURRENT STATUS: Closed

EXPT. NO. AND DESCRIPTION: 380. Seed orchard of selected provenances from Sudeten Mountains

LOCATION(S): PNFI

CURRENT STATUS: Closed

EXPT. NO. AND DESCRIPTION: 381-A-1. Interspecific hybridization

LOCATION(S): Meridian Road (PA101), PNFI

SITE DESCRIPTION(S): Previously a birch plantation; originally farmland fresh, sandy loam, sloping to west

DATE ESTABLISHED

Sown:	1971
Transplanted:	1973
Planted:	1975 (2 + 2)
Spacing:	7' x 7'

DESIGN

Reps:	1
Plot type/size:	6 tree row plots
Total # trees:	102

MATERIAL: Two op families of *L. decidua*; two op families of *L. decidua* x *occidentalis*; one op family of *L. decidua* x *laricina*; one op family of *L. laricina*; one selfed family of *L. laricina*; two op families of *L. sibirica* x *laricina*; one op family of *L. occidentalis*

EXPT. NO. AND DESCRIPTION: 381-A-2. Interspecific hybridization of European and Siberian larch

LOCATION(S): McDonald's field (PA104), PNFI

SITE DESCRIPTION(S): Former farmland with heavy poplar growth. Heavy sod and grass cover. Fresh, loamy sand

DATE ESTABLISHED

Sown:	1971
Transplanted:	1973
Planted:	1975 (2 + 2)
Spacing:	8' x 8'

DESIGN

Reps:	1
Plot type/size:	Row plots, variable size
Total # trees:	355

MATERIAL: Three op families of *L. decidua*; five op families of *L. decidua*; four op families of *L. sibirica*; two "control" lots of *L. sibirica*; eight op families of *L. sibirica* x *decidua*

EXPT. NO. AND DESCRIPTION: 381-A-3. Interspecific hybridization of European and Japanese larch

LOCATION(S): McDonald's Field West (PNFI)

SITE DESCRIPTION(S): Deep loamy sand

DATE ESTABLISHED

Sown:	1971
Transplanted:	1973
Planted:	Spring 1975
Spacing:	1.8 x 1.8 m

DESIGN

Reps:	10
Plot type/size:	10-tree row plots (unbalanced no. of trees per seedlot)
Total # trees:	1746 exp. plants

MATERIAL: 24 seedlots (four cp, 20 op) of crosses of Japanese larch x (European, *sibirica*) of various origins and obtained through several countries and institutions

DATA/MEASUREMENTS

Height:	9, 17 (five trees per row, and only 19 seedlots in block 1, 2, 6, 7, 9, 10)
Diameter:	17 runts rejected
Survival:	Avge. 67% at age 9 (range: 40% - 85%)
Damage:	Porcupine, forks

CURRENT STATUS: Blocks 3, 4, 5, and 8 are unsuited for measurements due to patchy mortality. Given the complexity of the genetic structure in the sampled material it is questionable whether this study merits further attention

SUMMARY: Survival at age 9 was significantly better in the Carpathian and Sudeten seedlots (84%) than in the Japanese seedlot from Honshu (40%). In 1987 (age 17) 16% of the trees were forked (no seedlot effects P>.14), and 19% of the trees had porcupine damage (the Polish seedlot 7286 with 50% damaged was the worst hit and the best were seedlots 7283 and 7265 with only 7% damaged trees; significant difference P<.05). Height at age 9 showed a strong differentiation among seedlots. Among the nine best seedlots, eight were Japanese sources and one (the best) was European (Carpathian, h = 3.9 m ± 0.4). Generally, Japanese sources outgrew European sources by 18% (P<.001). At age 17 the best seedlot (7283, Japanese v. Denmark) reached 10.6 m. Seven out of the nine best seedlots were Japanese; again Japanese seedlots were significantly better than *L. decidua* (11%). Seedlot effects were highly significant (P<.001). Rank stability over age was very high (0.9**).

EXPT. NO. AND DESCRIPTION: 381-A-4. Observation plantation of Japanese larch

LOCATION(S): Young Creek (PA106), PNFI

SITE DESCRIPTION(S): Former birch plantation, sloping – lower area grassy and wet, silty; upper area sandy

DATE ESTABLISHED

Sown:	1971
Transplanted:	1973
Planted:	1975
Spacing:	8′ x 8′

DESIGN

Reps:	1
Plot type/size:	7 x 16 block plots
Total # trees:	220

MATERIAL: Two seedlots of *L. leptolepis* from Japan (Nagano Ken & Kuniyana)

EXPT. NO. AND DESCRIPTION: 381-B-1. Open-pollinated progeny test of European larch

LOCATION(S): Pine Graft Arboretum (PA115), PNFI

SITE DESCRIPTION(S): Former mixed hardwood site; uniform but with some compaction due to stump removal. Sandy, with loamy and silty patches

DATE ESTABLISHED

Sown:	1972
Transplanted:	1974
Planted:	1976 (2 + 2)
Spacing:	6′ x 6′

DESIGN

Reps:	5 (+ filler block)
Plot type/size:	10-tree row plots
Total # trees:	400

MATERIAL: Eight op families of *L. decidua* from old PNFI plantations

DATA/MEASUREMENTS

Height:	Age 15
Diameter:	Age 15

CURRENT STATUS: Parts of three replications have poor survival and growth, but overall are in good condition.

EXPT. NO. AND DESCRIPTION: 381-B-2. Comparison of larch species and hybrids

LOCATION(S): Lake Doré, Ont.

SITE DESCRIPTION(S): Former pasture land, partly grown in with cedar, ironwood, and maple on gravelly and silty calcareous soil

DATE ESTABLISHED

Sown:	1972
Transplanted:	1974
Planted:	1976 (2 + 2)
Spacing:	6′ x 6′

DESIGN

Reps:	1
Plot type/size:	triple rows of hybrids surrounded by controls
Total # trees:	1126

MATERIAL: Seven op and 19 cp families of *L. decidua* (partial Design I and Design II); one op family of *L. gmelini* and two *L. gmelini* x *decidua* hybrids; two *L. decidua* x *sibirica* hybrids; one *L. eurolepis* seedlot

DATA/MEASUREMENTS: Height: Age 3, 4, 5

CURRENT STATUS: Good survival and growth (› 1 m/yr)

SUMMARY: Alpine x Sudeten *L. decidua* most productive (5-yr height: 6.0 - 7.0 m). *L. eurolepis* seedlot ranked 4th (7.0 m) – only 9 cm shorter than tallest. *L. gmelini* and hybrids and *L. sibirica* hybrids among poorest performers.

EXPT. NO. AND DESCRIPTION: 381-B-3. Open-pollinated progeny test of European larch

LOCATION(S): Fort Frances, Ont.

DATE ESTABLISHED

Sown:	1972
Transplanted:	1974
Planted:	1976 (2 + 2)
Spacing:	10′ x 10′

DESIGN

Reps: 5
Plot type/size: Block plots, 3 x 10 and 2 x 10
Total # trees: 550

MATERIAL: Four op families of Alpine *L. decidua* (via Farum, Denmark and PNFI)

CURRENT STATUS: Poor survival due to extreme drought in year of planting, as well as grass competition

SUMMARY: Seedlots 7393 and 7411 showed some tolerance to drought – best trees approximately 4.5 m at age 12 (less than local tamarack plantation) and growing at ~0.76 m/yr.

EXPT. NO. AND DESCRIPTION: 382. Provenance experiment of Siberian larch

CURRENT STATUS: Closed (never established?)

EXPT. NO. AND DESCRIPTION: 386-A. Larch plus trees on trial at the Northern Institute for Forest Genetics (WI)

LOCATION(S): Rhinelander, WI

DATE ESTABLISHED Sown: grafted 1974

MATERIAL: Scions from plus trees at PNFI plantation

SUMMARY: No information since 1974.

EXPT. NO. AND DESCRIPTION: 386-B. Larch plus trees in trial in the Maritimes (clones)

LOCATION(S): Forestry Canada-Maritimes, Fredericton, N.B.

DATE ESTABLISHED Sown: 1973 grafted

MATERIAL: Scions sent from PNFI plus trees

SUMMARY: No information since 1973.

EXPT. NO. AND DESCRIPTION: 386-C. Larch plus trees on trial in Québec

LOCATION(S): Duchenay nursery

DATE ESTABLISHED Sown: grafted 1973-1975

MATERIAL: Scions from plantations at PNFI. *Larix decidua, L. leptolepis, L. sibirica, L. laricina*

CURRENT STATUS: Active

SUMMARY: A clonal archive of the best larch trees.

EXPT. NO. AND DESCRIPTION: 424-1. Local tamarack seed sources sent to OMNR, Maple for biomass studies

DATE ESTABLISHED Sown: 1977

CURRENT STATUS: Unknown.

EXPT. NO. AND DESCRIPTION: 424-3. Range-wide tamarack sent to Lakehead University for mycorrhizal studies

DATE ESTABLISHED Sown: seed sent 1984

CURRENT STATUS: Unknown.

EXPT. NO. AND DESCRIPTION: 424-4. Range-wide tamarack test in Québec

CURRENT STATUS: Unknown.

EXPT. NO. AND DESCRIPTION: 424-5. Range-wide tamarack test in the Maritimes

DATE ESTABLISHED Sown: 1983

MATERIAL: Range-wide tamarack seed sent to Yellowstone Park

CURRENT STATUS: Unknown.

EXPT. NO. AN DESCRIPTION: 424-6. Range-wide tamarack provenance trial at PNFI

LOCATION(S): PNFI, PA125 Sugarbush area

DATE ESTABLISHED

Sown:	1985
Planted:	1986
Spacing:	2 x 2 m

DESIGN

Reps:	2 x 25
Plot type/size:	2 interlocking replications
Total # trees:	2900

MATERIAL: 58 seedlots of range-wide tamarack

CURRENT STATUS: Active

SUMMARY: In good condition.

EXPT. NO. AND DESCRIPTION: 424-7. Range-wide tamarack provenance trial in Newfoundland

DATE ESTABLISHED: Sown: 1986

CURRENT STATUS: Unknown.

EXPT. NO. AND DESCRIPTION: 424-8. Range-wide tamarack provenance trial in Espanola, Ontario

LOCATION(S): Espanola, Ontario

SITE DESCRIPTION(S): Loamy-sand, abandoned farm

DATE ESTABLISHED

Sown:	1986
Planted:	1987
Spacing:	1 x 1 m

DESIGN

Reps:	2 x 25 interlocking
Plot type/size:	1 tree
Total # trees:	3000

CURRENT STATUS: Active

SUMMARY: Good condition.

EXPT. NO. AND DESCRIPTION: 424-9. Range-wide tamarack provenance planted in Hearst, Ontario

LOCATION(S): Hearst, Ontario

SITE DESCRIPTION(S): Sandy-loam jack pine – poplar cutover

DATE ESTABLISHED

Sown:	1986
Planted:	1987
Spacing:	1 x 1 m

DESIGN

Reps:	2 x 25 interlocking
Plot type/size:	1 tree
Total # trees:	3000

MATERIAL: 49 seedlots of range-wide tamarack

CURRENT STATUS: Active

SUMMARY: Good condition.

EXPT. NO. AND DESCRIPTION: 424-10. Open-pollinated family test of tamarack.

LOCATION(S): PNFI PA115

SITE DESCRIPTION(S): Flat, level site, previously carrying plantations of European, Siberian, and Japanese larches; completely cultivated.

DATE ESTABLISHED

Sown:	1988
Planted:	1989
Spacing:	1m x 2m

DESIGN

Reps:	12
Plot type/size:	2-tree plots with interlocking blocks
Total # trees:	3100

MATERIAL: 130 open-pollinated families from 25 populations in Ontario and Québec.

CURRENT STATUS: Planted 1989.

EXPT. NO. AND DESCRIPTION: 424-11. Open-pollinated family test of tamarack.

LOCATION(S): Espanola, Ontario

SITE DESCRIPTION(S): Level, flat sandy loam, completely cultivated.

DATE ESTABLISHED

Sown:	1987
Planted:	1988
Spacing:	2m x 2m

DESIGN

Reps:	25
Plot type/size:	single-tree plot
Total # trees:	3500

CURRENT STATUS: Abandoned 1989; 50% drought-related mortality.

EXPT. NO. AND DESCRIPTION: 424-12. Open-pollinated family test of tamarack.

LOCATION(S): Hearst, Ontario

SITE DESCRIPTION(S): Flat, level cutover--previously white spruce and hardwoods.

DATE ESTABLISHED

Sown:	1987
Planted:	1988
Spacing:	2m x 2m

DESIGN

Reps:	25
Plot type/size:	single tree plots
Total # trees:	3000

MATERIAL: 120 open-pollinated seedlots from 25 populations in Ontario, Québec, and the Prairie provinces.

CURRENT STATUS: 95% survival after one year

EXPT. NO. AND DESCRIPTION: 428A, B1,2,4, C,D,F,H. Provenance tests/seed production areas of Japanese larch

LOCATION(S): PNFI/Gloucester Twp., Ont./Kenyon Twp., Ont./Oxford Twp., Ont./Yange Twp., Ont./Kemptville, Ont./Edwardsburg, Ont./Burritts Rapids, Ont./Quebec, Que./Newfoundland

DATE ESTABLISHED Sown: 1978/79

CURRENT STATUS: Closed/dormant/active.

EXPT. NO. AND DESCRIPTION: 428-B-3. Provenance test of Japanese larch

LOCATION(S): Edwardsburg Land Assembly area, Ontario

DATE ESTABLISHED

Sown:	1977
Planted:	1979
Spacing:	2.4 x 3 m

DESIGN

Reps:	2
Plot type/size:	100 trees/plot
Total # trees:	4200

MATERIAL: 21 seedlots

DATE/MEASUREMENTS Other: survival 1979

CURRENT STATUS: Active.

EXPT. NO. AND DESCRIPTION: 428-E-1-(2). Japanese larch seed production orchard

LOCATION(S): Edwardsburg Land area, Ontario, OMNR
Burritts Rapids, Ontario, OMNR

DATE ESTABLISHED
Sown: 1978
Planted: 1980

DESIGN
Reps: 5
Plot type/size: 10
Total # trees: 3900

MATERIAL: 78 seedlots

DATE/MEASUREMENTS
Height: 1983
Survival: 1983
Other: analysis 1983

CURRENT STATUS: Active

SUMMARY: Good condition.

EXPT. NO. AND DESCRIPTION: 428-G-1. Japanese larch seedling seed orchard

LOCATION(S): Batiscan, Que. (C.I.P.)

DATE ESTABLISHED
Sown: 1978
Planted: 1980

DESIGN
Reps: 10
Plot type/size: 10

MATERIAL: 79 seedlots

DATA/MEASUREMENTS:
Height: 1983
Survival: 1983
Other: Frost ratings

CURRENT STATUS: Active

SUMMARY: Good.

EXPT. NO. AND DESCRIPTION: 429-A. Exotic larch hybrid clonal seed orchard

LOCATION(S): Codrington, OMNR. Moved to Crystal Rock

DATE ESTABLISHED Planted: 1981

MATERIAL: European and Japanese larch

CURRENT STATUS: Closed.

EXPT. NO. AND DESCRIPTION: 429-B-2. Exotic larch hybrid clonal seed orchard

LOCATION(S): Harrington Forest Farm, Aurora, Québec

SITE DESCRIPTION(S): Poorly drained sand over clay along the Rouge River and road to Armdel

DATE ESTABLISHED
Sown: grafting 1980
Planted: 1981

MATERIAL: 150 *Larix decidua;* 984 *L. leptolepis*

CURRENT STATUS: Active.

EXPT. NO. AND DESCRIPTION: 440-1. Development of European larch land race for seed production and improvements

LOCATION(S): PNFI PA140. Unit Creek plantation area

SITE DESCRIPTION(S): Loamy-sand with bedrock and depressions poorly drained

DATE ESTABLISHED
Sown: grafting 1980-1983
Planted: 1983-1984
Spacing: 4 x 4 m

DESIGN
Reps: 5
Plot type/size: 1 tree/plot
Total # trees: 750

MATERIAL: 150 clones

DATA/MEASUREMENTS Survival: 1986

CURRENT STATUS: Active

SUMMARY: Plantation in good condition.

EXPT. NO. AND DESCRIPTION: 441-1. Japanese larch clonal seed orchard

LOCATION(S): PNFI PA131-C, Sturgeon Lake Road

SITE DESCRIPTION(S): Sandy flat

DATE ESTABLISHED

Planted:	1985
Spacing:	5 x 5 m

DESIGN

Reps:	2
Plot type/size:	1
Total # trees:	150

MATERIAL: 75 clones from Japanese larch from Harrington Forest Farm of unknown origin

CURRENT STATUS: Active

SUMMARY: Alive and well.

EXPT. NO. AND DESCRIPTION: 441-2. Japanese larch clonal seed orchard

LOCATION(S): PNFI PA115. Pine graft arboretum

SITE DESCRIPTION(S): Sandy, susceptible to frost

DATE ESTABLISHED:

Planted:	1985
Spacing:	5 x 5 m

DESIGN

Reps:	2
Plot type/size:	1
Total # trees:	150

MATERIAL: 75 clones from Japanese larch from Harrington Forest Centre of unknown origin

CURRENT STATUS: Active

SUMMARY: Good condition.

EXPT. NO. AND DESCRIPTION: 442-1. Testing of second generation open pollinated larch from PNFI plantations

LOCATION(S): Espanola, Ontario. (E.B. Eddy Corporation)

SITE DESCRIPTION(S): Sandy

DATE ESTABLISHED Planted: 1986

CURRENT STATUS: Unknown.

EXPT. NO. AND DESCRIPTION: 442-2. Testing of second generation open pollinated larch from PNFI plantations

LOCATION(S): Seed sent to Lakehead University

DATE ESTABLISHED Sown: 1986

CURRENT STATUS: Unknown.